



Escapement efficiency through a square mesh panel In: ICES (2012) Report of the ICES-FAO Working Group on Fishing Gear Technology and Fish Behaviour (WGFTFB), 23-27 April 2012, Lorient, France. ICES CM 2012/SSGESST:07

Herrmann, Bent; Wienbeck, H.; Karlsen, Junita; Dahm, E.; Moderhak, W.; Stepputtis, D.

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

Citation (APA):

Herrmann, B., Wienbeck, H., Karlsen, J., Dahm, E., Moderhak, W., & Stepputtis, D. (2012). *Escapement efficiency through a square mesh panel In: ICES (2012) Report of the ICES-FAO Working Group on Fishing Gear Technology and Fish Behaviour (WGFTFB), 23-27 April 2012, Lorient, France. ICES CM 2012/SSGESST:07*. Abstract from ICES-FAO Working Group on Fishing Gear Technology and Fish Behaviour (WGFTFB) , Lorient, France, France.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

ICES WGFTFB REPORT 2012

SCICOM STEERING GROUP ON ECOSYSTEM SURVEYS SCIENCE AND TECHNOLOGY

ICES CM 2012/SSGESST:07

REF. SCICOM, ACOM

Report of the ICES–FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB)

23–27 April 2012

Lorient, France



ICES

International Council for
the Exploration of the Sea

CIEM

Conseil International pour
l'Exploration de la Mer

International Council for the Exploration of the Sea Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2012. Report of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB), 23-27 April 2012, Lorient, France. ICES CM 2012/SSGESST:07. 206 pp.

For permission to reproduce material from this publication, please apply to the General Secretary.

The document is a report of an Expert Group under the auspices of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council.

© 2012 International Council for the Exploration of the Sea

Contents

Executive summary	1
1 Directive	4
2 Introduction	4
3 Terms of Reference.....	5
4 Participants	6
5 Explanatory note on meeting and report structure.....	6
6 Opening of the meeting.....	6
7 Report from ICES (Mike Pol)	6
7.1 Developments in the ICES-FAO relationship in regards to WGFTFB.....	6
7.2 Report on developments from the 2011 Annual Science Conference.....	7
7.2.1 The Marine Framework Strategy Directive (MFSD)	7
7.2.2 MSFD vs. WGFTFB – a very quick guide (Tom Catchpole).....	7
7.2.3 Ecosystem Surveys	8
7.2.4 Communication with ICES Advisory Committee (ACOM)	8
7.3 Multi-annual Management of SCICOM Expert Groups	9
7.4 Request on data collection on marine litter during surveys	10
7.5 ICES Advice on Data Collection Framework.....	11
7.6 Nominations for ICES prizes.....	12
7.7 Other comments.....	13
8 Report from FAO (Petri Suuronen)	13
9 Presentation of Expert Group reports	15
9.1 Report from the Study Group on Turned 90° Codend Selectivity (SGTCOD; Bent Herrmann)	15
9.2 Report from Study Group on Electrical Trawling (SGELECTRA; Bob van Marlen).....	17
10 ToR A: Incorporation of Fishing Technology Issues/Expertise into Management Advice (Mike Pol and Dominic Rihan)	20
10.1 General Overview.....	20
10.2 Terms of Reference	20
10.3 General issues.....	20
10.4 Information for individual assessment working groups.....	33
10.5 Conclusions	34
11 ToR B: Redfish Fishing Technology and Physiology (Bent Herrmann)	35
11.1 Background.....	35

11.2	General Overview.....	35
11.3	Terms of Reference	35
11.4	List of Participants.....	36
11.5	Individual presentations.....	36
11.5.1	A Network to Redevelop a Sustainable Redfish (<i>Sebastes fasciatus</i>) Trawl Fishery in the Gulf of Maine (Mike Pol, Mass. Division of Marine Fisheries, USA).....	36
11.5.2	Grid selectivity for redfish (Bent Herrmann, DTU-Aqua)	36
11.5.3	Sticking of redfish in trawl netting (Discussion)	37
11.5.4	Some aspects of Redfish Selectivity (A. Pavlenko, PINRO, Russian Federation).....	37
11.5.5	New Data from Iceland (O. Ingolfsson, Marine Resources Institute)	39
11.6	Recommendations and findings.....	39
12	ToR C: Use of Artificial Light in Fishing (Heui-Chun An, Mike Breen, Odd-Børre Humborstad, Yoshiki Matsushita)	40
12.1	Terms of Reference	40
12.2	Introduction.....	40
12.3	List of Participants.....	41
12.4	Background.....	41
12.5	Session 1 – An introduction to the properties of light underwater and the biology of underwater vision.....	43
12.5.1	Light and Vision: Use of Artificial Light in Fishing Operations (Christopher W. Glass).	43
12.5.2	Colour vision in fish – pigment adaptability and lens flexibility (Anne Christine Utne Palm).	44
12.6	Session 2 – National/Regional overviews of the use of artificial light in fisheries, and any associated research.....	46
12.6.1	An overview of the use of artificial light in world fisheries (Mike Breen)	46
12.6.2	Artificial light in fishing in France (S. Méhault and F. Morandeau)	47
12.6.3	Attraction and trapping of cod using artificial light (Einar Hreinsson).....	48
12.6.4	The use of artificial light in fisheries (and associated researches) in Japan and the Pacific region (Yoshiki Matsushita)	48
12.6.5	Use of artificial light in Asian fisheries (Heui Chun An)	50
12.6.6	Energy saving effect of LED fishing lamps for angling and jigging boats (Heui Chun An, Bong Seong Bae, Kyoung Hoon Lee, Seong Jae Jeong, Jae Hyun Bae and Seong Wook Park).....	51
12.6.7	Grazing cod on euphausiids in pen – reduced feeding? (Hjalti Karlsson)	52
12.6.8	Use of artificial light in Norwegian fisheries (Svein Løkkeborg).....	53

12.6.9	Use of artificial light in Basque fisheries (Luis Arregi).....	54
12.6.10	Artificial light, increasing catch in cod pots? (Sven Gunnar Lunneryd, Sara Königson and Mikael Ovegård).....	54
12.6.11	The use of artificial light in fisheries in the USA – (Pingguo He).	55
12.7	Session 3 – New and innovative applications of artificial light in conservation-oriented fishing gear designs	56
12.7.1	Current research on colour and light and its application in conservation-oriented fishing gear designs (Pingguo He).....	56
12.8	Session 4 – Discussion on the status and recommendations of the Topic Group.....	58
12.9	Recommendations	60
13	ToR D: Innovation in Fishing Gear Technology (Bob van Marlen).....	62
13.1	General overview	62
13.2	Terms of Reference	62
13.3	List of Participants	62
13.4	Opening of the meeting	63
13.5	Adoption of the agenda	63
13.6	Individual presentations.....	63
13.6.1	Innovative Fishing Gears in The Netherlands (Bob van Marlen).....	63
13.6.2	Energy efficiency analysis for Italian fishing vessels through an Energy Audit tool (Antonello Sala, Gabriele Buglioni, Emilio Notti).....	66
13.6.3	The Swedish Grid (Hans Nilsson).....	67
13.6.4	Gear innovation to reduce cod capture in the Scottish Nephrops fishery: the flip/flap and FCAP trawls (Barry O'Neill).....	68
13.6.5	Prediction of the vertical forces applied on the seabed by a trawl gear (Francois Theret).	71
13.6.6	The effect of introducing pulse trawling in North Sea fisheries on a range of fish major target species (Bob van Marlen).....	71
13.6.7	Innovative Low Impact and Fuel Efficient (LIFE) fishing practices (Petri Suuronen).....	72
13.6.8	DynamiT demonstration (Benoit Vincent)	74
13.7	General discussion.....	74
13.8	Summary of lessons learned in this ToR	75
13.9	Recommendations	76
14	Open session.....	77
14.1	Consideration on Low Impact and Fuel Efficient Fishing: Comparing Squid Jigging and Large-scale fish trap fisheries in western Japan (Yoshiki Matsushita).....	77
14.2	Energy efficiency analysis (Emilio Notti).....	78

14.3	A Low-Cost, Underwater Self-Closing Codend to Limit Unwanted Catch (Mike Pol for Dave Chosid).....	80
14.4	Development of catch control devices in trawl fisheries (Manu Sistiaga for Eduardo Grimaldo).....	81
14.5	A Decade of Research on Shrimp Trawl Design to Reduce Fish Bycatch and Small Shrimps (Pingguo He)	83
14.6	The utility of square mesh codends in UK OTB (Tom Catchpole)	86
14.7	Quantifying fish escape behavior through large mesh panels in trawls based on catch comparison data: model development and a case study from Skagerrak (Ludvig Krag, Bent Hermann, & Junita D. Karlsen)	88
14.8	Escapement efficiency through a square mesh panel (Bent Herrmann, Harald Wienbeck, Junita D. Karlsen, Erdmann Dahm, Waldemar Moderhak & Daniel Stepputtis)	89
14.9	Slipping from purse-seines – Simply a source of unaccounted mortality or a potentially responsible way of controlling the catches (Maria Tenningen)	90
14.10	Predicting and mitigating the benthic impact of towed gears – a case study with a clump weight (F.G. O'Neill, A. Ivanovic, L. Robinson and R. J. Fryer).....	91
14.11	Catch comparison of pulse trawl vessels and a tickler chain beam trawler (Bob van Marlen).....	94
14.12	Measuring sediment mobilization by fishing gears using a Multi Beam Echo Sounder (F.G. O'Neill, Dan Parsons, Steve Simmons, J Best, Phil Copland, Eric Armstrong, Mike Breen and Keith Summerbell)	96
14.13	Prediction of the vertical forces applied on the seabed by a trawl gear (Francois Theret)	97
14.14	Light and vision (Chris Glass)	98
14.15	Synthesis of International Fishing Gear Laboratories Organization (Sonia Mehault).....	99
15	National Reports	101
15.1	Review of National Reports (Mike Pol).....	101
15.2	Canada	102
15.2.1	Fisheries and Marine Institute of Memorial University of Newfoundland	102
15.2.2	Fisheries and Oceans Canada – Central and Arctic Region.....	104
15.2.3	Fisheries and Oceans Canada – Maritimes Region	104
15.2.4	Merinov Centre d'Innovation de l'Aquaculture et des Pêches du Québec	105
15.2.5	Simon Fraser University and Vancouver Island University	106
15.3	France	107
15.3.1	Ifremer Fishing gear technology laboratory.....	107
15.4	Iceland	109
15.4.1	Marine Research Institute	109

15.5	Ireland	110
15.5.1	Bord Iascaigh Mhara.....	110
15.6	Italy	111
15.6.1	National Research Council (CNR). Institute of Marine Sciences (ISMAR) – Fisheries Section, Ancona	111
15.7	Japan	114
15.7.1	Fishing Technology Laboratory, Graduate School of Fisheries Science and Environmental Studies, Nagasaki University	114
15.7.2	Nagasaki Prefectural Institute of Fisheries.....	115
15.7.3	Department of Fisheries Science, Faculty of Agriculture, Kinki-Daigaku University, Study Group of Fishing Technology and Fish Behaviour	115
15.7.4	School of Fisheries Sciences, Hokkaido University.....	116
15.8	Netherlands	117
15.8.1	IMARES/ILVO.....	117
15.9	Norway	122
15.10	Spain (Basque region)	128
15.10.1	AZTI Tecnalia (Technological Institute for Fisheries and Food; www.azti.es) by the Marine and Fishing Gear Technology Research Area.	128
15.11	Scotland.....	130
15.11.1	Marine Scotland – Science, Marine Laboratory, Aberdeen.....	130
15.12	USA	131
15.12.1	Massachusetts Division of Marine Fisheries – Conservation Engineering Program.....	131
15.12.2	NOAA Fisheries, Northeast Fisheries Science Center, Protected Species Branch, Woods Hole, Massachusetts	132
15.12.3	University of Rhode Island Fisheries Center, Kingston, Rhode Island.....	133
15.12.4	University of Rhode Island, Kingston, Rhode Island.....	135
15.12.5	Consortium for Wildlife Bycatch Reduction	135
15.12.6	University of Massachusetts Dartmouth, School for Marine Science and Technology (SMAST), New Bedford, MA	137
15.12.7	NOAA Fisheries, Southeast Fisheries Science Center	141
15.12.8	NOAA Fisheries, Southwest Region and Southwest Fisheries Science Center, La Jolla, California	144
15.12.9	Oregon Department of Fish and Wildlife, Marine Resources Program, Newport, Oregon.....	146
15.12.10	NOAA Fisheries, Northwest Fisheries Science Center, Seattle, Washington	147
15.12.11	NOAA Fisheries, Alaska Fisheries Science Center, Seattle, Washington	149
15.12.12	NOAA Fisheries, Pacific Islands Region and Pacific Islands Fisheries Science Center, Honolulu, Hawai'i.....	150

15.13 Discussion of National Reports	151
16 Other business.....	152
16.1 SELDAT database	152
16.2 Theme Session Topics for ICES ASC 2013.....	152
16.3 2013 Annual Meeting	152
16.3.1 Location.....	152
16.3.2 Meeting Structure	153
16.3.3 Terms of Reference for 2013	154
16.4 AOB and concluding remarks.....	155
Annex 1: List of Participants.....	156
Annex 2: Agenda.....	162
Annex 3: WGFTFB terms of reference for the next meeting.....	165
Annex 4: Recommendations	169
Annex 5: WGFTFB information for other ICES expert groups and questionnaire sent to WGFTFB members	170
Annex 6: A Partial Global Summary of the Fisheries Using Artificial Light.....	191
Annex 7: Bibliography for Use of Artificial Light in Fisheries.....	198

Executive summary

The ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB) met in Lorient, France from 23–27 April 2012 to address four Terms of Reference. The main outcomes related to the ToRs are detailed below.

Key Findings

ToR A: Incorporation of Fishing Technology Issues/Expertise into Management Advice (Section 10)

- As in the last previous 3–4 years fuel prices were the dominant feature in all countries that affected fleet dynamics. Rising costs were manifested in multiple ways: shifts in gear, modifications to fishing practices, changes in vessel powering. Of particular note is the shift in the Netherlands away from traditional beam trawling to the use of the pulse trawl and the Sum Wing. It is now apparent that within the Netherlands, driven primarily by the cost of fuel, there is a huge demand to use the pulse trawl and the number of vessels applying to fish under the 5% derogation far exceeds the number of licences available. Vessels not using the pulse trawl in the Netherlands are finding it increasingly difficult to get financial support from banks on economical (high fuel prices making beam trawling uneconomic) and ecological grounds (beam trawls are portrayed negatively).
- As in previous years there is very little evidence of technology creep. Most changes are related to improving fuel efficiency measures. In the Netherlands and Belgium uptake of the SumWing has increased. The development of fuel efficient trawl designs, off-bottom doors in demersal trawling and the use of Dynex warp seen in 2010 and 2011 seems to have spread to many countries.
- Uptake of selective gears continues to be limited and driven primarily by legislation. Interesting developments include the SELTRA used in Denmark and also tested in Ireland and also the Flip-flap trawl developed in the UK. Both of these devices are designed to reduce cod catches in demersal fisheries.
- Discarding due to quota closures was especially noted in Ireland and Spain. Shifts in discarding rates were linked to population changes in Ireland and France.
- A number of gear modifications have been tested and in some cases are being used to reduce the bottom impact of towed gears. As reported under Technical Creep there has also been considerable testing of trawl doors rigged to fish off-bottom, primarily driven by fuel prices. Both initiatives potentially have benefits in respect of reduced bottom impact.
- Virtually no new fisheries were been reported in 2012. Experimentation of static gears as a means for targeting fish has continued although the indications are that these fisheries are still not economically viable in most cases.

ToR B: Redfish fishing technology and physiology (Section 11)

- Terms of reference have been achieved to an acceptable level.
- Collaborations have been established between members and will continue outside the context of meetings of WGFTFB. One published paper (Herrmann, B. *et al.*, 2012. Understanding the Size Selectivity of Redfish (*Sebastes* spp.) in North Atlantic Trawl Codends. Journal of Northwest Atlantic Fishery Science, 44, pp.1–13) and others in development arose from the topic group.
- The group should be dissolved.

ToR C: The Use of Artificial Light in Fisheries (Section 12)

- The group reviewed the terms of reference and agreed that it would be necessary to address aims 1–3, before aims 4 and 5 could be completed. Therefore, priority should be given to tasks associated with aims 1–3 in the first year of the groups work.
- It was agreed that in order to support the activities of the group in addressing these ToRs the group would need to recruit further expertise in each of the following areas:
 - physics and measurement of artificial light in water;
 - engineering and design of artificial lights, including the development of energy efficient light sources;
 - biology of vision, in particular recognition of the natural limits and variation;
 - behavioural responses of fish to artificial light; and
 - technological application of artificial light in fisheries, including novel and innovative approaches.

Potential candidates were identified and will be contacted.

- The ICES/FAO WGFTFB Topic Group on the Use of Artificial Light in Fisheries makes the following recommendations to the ICES/FAO WGFTFB:
 - The Topic Group on the Use of Artificial Light in Fisheries should continue working by correspondence and meetings (at next WGFTFB meeting) under amended terms of reference (see below);
 - It is proposed a theme session should be held at the next ICES/FAO WGFTFB meeting on “the use of artificial light as a stimulus on fish behaviour in fish capture”; and
 - The Topic Group supports the proposal for the next WGFTFB meeting to be held in Asia. This venue will facilitate the development and work of this group, by opening lines of communication with experts in Asia currently working in the field of light fishing.
- Amended Terms of Reference:
 - *A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions.*
 - *Specifically the group aims to:*

- *Describe and summarize fish response to artificial light stimuli;*
- *Describe and summarize use of artificial light in world fisheries;*
- *Describe and tabulate different light sources to attract fish;*
- *Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions;*
- *Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods; and*
- *Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture.*

ToR D: Innovation in Fishing Gear Technology (Section 13)

- It was acknowledged that the working scene is changing. Fishermen have PCs too, they use Internet more and more, are aware of threats to the fishing industry, have own ideas and creativity, and are not waiting for us.
- Good incentives are needed for successful innovation, such as: cost reductions (fuel price !!!), more days-at-sea (DAS) when using selective gears, or access to fishing grounds only if selective gears are used.
- Fishermen Study Groups (as in The Netherlands) can be used help the process of innovation. They create more motivation, and a sense of problem ownership by the fishers.
- Scientists should have a role in innovation. Developments by industry alone may lead to unwanted ecosystem effects. WGFTFB has an international view and wide experience, knowledge of gears, behaviour, statistics, and suitable instrumentation (e.g. RCTV).
- Group interactions between fishers often occur, resulting in differing behaviour. Experience shows that it is sometimes better to address a single individual and work with him, and then others will follow when they see results.
- Trust building and communication are important, but trust is easily lost.
- There is a tension between the objectives of creating more efficiency and ecosystem conservation. In order to survive businesses need efficiency and income exceeding costs, but on the other hand ecosystem constraints and conservation do not ask for more efficient gears and higher catches.
- This ToR will not be continued.

1 Directive

The directive of the WGFTFB is to initiate and review investigations of scientists and technologists concerned with all aspects of the design, planning and testing of fishing gears used in abundance estimation, selective fishing gears for bycatch and discard reduction, as well as benign environmentally fishing gears and methods with reduced impact on the seabed and other non-target ecosystem components.

The Working Group's activities shall focus on all measurements and observations pertaining to both scientific and commercial fishing gears, design and statistical methods and operations including benthic impacts, vessels and behaviour of fish in relation to fishing operations. The Working Group shall provide advice on application of these techniques to aquatic ecologists, assessment biologists, fishery managers and industry.

2 Introduction

Chair:	Michael Pol Massachusetts Division of Marine Fisheries 1213 Purchase St – 3rd Floor New Bedford, Massachusetts USA E-mail: mike.pol@state.ma.us
Co-Chair:	Petri Suuronen FAO Fisheries and Aquaculture Department Rome Italy E-mail: petri.suuronen@fao.org
Rapporteur:	Bob van Marlen IMARES, Wageningen UR Ijmuiden The Netherlands E-mail: bob.vanmarlen@wur.nl
Venue:	Lorient, France
Date:	23–27 April 2012

3 Terms of Reference

2011/2/SSGESST07 The ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB), chaired by Mike Pol, US, and Petri Suuronen, FAO-Rome, met in Lorient, France, 23–27 April 2012.

- a) Incorporation of Fishing Technology Issues/Expertise into Management Advice. Based on the questionnaire exercise carried out since 2005/2006;
- b) A WGFTFB topic group of experts formed in 2011 will meet in 2012 with the following terms of reference:
 - i) Create an inventory of gear specifications (such as mesh size, trawl design, trawl orientation) used in harvesting redfish in member countries;
 - ii) Describe and synthesize research carried on size selectivity with various mesh sizes and configurations and investigate possible technical measures that could reduce the loss of redfish at the surface due to their developed buoyancy;
 - iii) Collect morphometric information necessary to predict size selectivity;
 - iv) Examine habitat use, especially water depth and water columns, by major commercial redfish species and application of the information for selective capture by trawls.
- c) A WGFTFB topic group of experts will meet in 2012 to continue to address the issue of Innovation in fishing gear technology and the success of collaboration between fishers and scientists with the following terms of reference:
 - i) Review current technological developments and initiatives in gear technology and give examples of successful developments both in the EU and in other countries globally;
 - ii) Discuss the contributions of fishers and scientists in the process of collaboration and identify conditions enabling rapid uptake of new technology, without the risk of introducing new adverse ecosystem effects;
 - iii) Consider the use of models with which the effect on the marine ecosystem (concerning target species, fish and benthos bycatches, bottom impact) of introducing new innovative gears in fishing fleets can be appraised.
- d) A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions. Specifically the group aims to:
 - i) Describe and summarize fish response to artificial light stimuli;
 - ii) Describe and summarize use of artificial light in world fisheries;
 - iii) Describe and tabulate different light sources to attract fish;
 - iv) Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions;

- v) Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods;

WGFTFB will report by 14 June 2012 (via SSGESST) for the attention of SCICOM and ACOM.

4 Participants

A full list of participants is given in Annex 1.

5 Explanatory note on meeting and report structure

The approach adopted in 2004 of addressing specific TORs was adopted for the 2012 meeting. Individual conveners were appointed during prior meetings to oversee and facilitate work by correspondence throughout the year and at the meeting. The Chair asked the convener of each ToR to prepare a working document, reviewing their progress on their ToRs and recommendations and conclusions based on the topic group's work. Two days were allocated for the conveners and members of the individual Topic Groups to meet, finalize their reports and findings, and produce a presentation to the WG and prepare a final report for inclusion in the FTFB report. The **summaries and recommendations** for the working documents for each ToR were reviewed by WGFTFB and were accepted, rejected or modified accordingly to **reflect the views of the WGFTFB**. However, the contents of these working documents do not necessarily reflect the opinion of the WGFTFB. Some topic groups included small numbers of individual presentations based on specific research programmes related to that topic. The abstracts are included in this report, together with the authors' names. Although discussion relating to the individual presentations was encouraged and some of the comments are included in the text of this report, the contents of the individual abstracts were NOT discussed fully by the group, and as such they **do not necessarily reflect the views of the WGFTFB**.

6 Opening of the meeting

The meeting was opened by the chair. Welcoming remarks were made, and logistics explained by Gerard Bavouzet of Ifremer, the host institution. Bob van Marlen (Netherlands) volunteered to serve as rapporteur, and was accepted by the WG.

Following a review by the chair to the group, the agenda was adopted as attached in Annex 2.

7 Report from ICES (Mike Pol)

7.1 Developments in the ICES–FAO relationship in regards to WGFTFB

An exchange of letters between Manuel Barange of ICES and A. G. Mathiesen of FAO in June 2011 elaborated the arrangements regarding WGFTFB under the existing ICES-FAO Memorandum of Understanding signed in 1996.

The exchange of letters defined the purpose of the relationship as facilitating collaboration and communication between the member countries of ICES and FAO to address all aspects of fishing technology and fish capture in order to further contribute to ensuring the sustainability of fisheries resources globally.

FAO will appoint a Co-Chair for WGFTFB, and organize the annual meeting every third year, beginning 2013. The meeting location will be in Rome, Italy or other location determined by FAO. In March 2012, SCICOM reinforced the ability of FAO to choose the location without restriction by ICES; with the understanding the member institutions may find it difficult to approve travel to some locations. Petri Suuronen co-chaired the 2012 meeting in Lorient, in place of Frank Chopin.

FAO-organized meetings will include a mini symposium format, with special consideration given to attendance by developing States. Thematic issues could include, among other topics:

- i) bycatch and discards;
- ii) fishing gear selectivity;
- iii) policy related to technical conservation measures;
- iv) reduction of aquatic and environmental damage associated with fishing operations including reducing greenhouse gas (GHG) emissions;
- v) fish behaviour in relation to fish capture processes;
- vi) low impact fuel efficient capture techniques;
- vii) fish detection, tracking and other remote sensing technologies used in fishing operations;
- viii) novel and innovative harvesting systems including live capture techniques.

7.2 Report on developments from the 2011 Annual Science Conference

7.2.1 The Marine Framework Strategy Directive (MFSD)

The Marine Framework Strategy Directive (MFSD) has a big impact. All ICES Working Groups (WGs) should emphasize biodiversity and other descriptors found in the MFSD, and ToRs should be made relevant to biodiversity and other aspects of the MFSD.

7.2.2 MSFD vs. WGFTFB – a very quick guide (Tom Catchpole)

The Marine Strategy Framework Directive (MSFD) aims to achieve Good Environmental Status in Europe's seas by 2020. Good Environmental Status (GES) involves protecting the marine environment, preventing its deterioration and restoring it where practical, while using marine resources sustainably. The Directive sets out 11 high-level Descriptors of Good Environmental Status which cover all the key aspects of the marine ecosystem and all the main human pressures on them.

Main relevance to WGFTFB (and the fishing industry): Achieving GES will involve both ensuring that commercial fish and shellfish stocks are harvested sustainably (MSFD Descriptor 3), and ensuring that the impacts of fishing activities on the wider marine ecosystem are sustainable (MSFD Descriptor 1, biodiversity, Descriptor 4, foodwebs and Descriptor 6, seabed integrity).

MSFD Descriptors for determining good environmental status are:

- 1) Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.

- 2) Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
- 3) Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
- 4) All elements of the marine foodwebs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
- 5) Human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
- 6) Seabed integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
- 7) Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
- 8) Concentrations of contaminants are at levels not giving rise to pollution effects.
- 9) Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
- 10) Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
- 11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

More information is given in:

http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm

<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF>

7.2.3 Ecosystem Surveys

SSGESST was asked with the input from Expert Groups (EGs) to develop programmes for ecosystem monitoring, and find efficiencies in response to reduced funding. The strategy will depend on whether a related Theme Session for 2012 is accepted. This will involve developing ToRs for WGISDAA and/or well-focused workshops. SSGESST will also establish a group of Survey EG chairs to develop a plan for review of surveys and survey Expert Groups and to propose action items for SSGESST in 2012/13, and it should also involve ACOM and STECF.

7.2.4 Communication with ICES Advisory Committee (ACOM)

The need for improved communication and coordination with ACOM has become increasingly apparent. WGFTFB has communicated with ACOM via WGCHAIRS and received positive feedback on the input provided to assessment groups via the reports generated each year by WGFTFB through the ADVICE ToR.

7.3 Multi-annual Management of SCICOM Expert Groups

In September 2011, after consultation with chairs of Expert Groups (EGs [EGs include Workshops (W/S), Study Groups (SG), and Working Groups (WGs)]), the ICES Science Committee (SCICOM) agreed to a staggered process of introducing multi-annual Terms of Reference (ToR), as part of 2009 reform of the science structure.

Goals:

- Reduce the burden of annual reporting on EGs, and provide the groups with a longer-perspective to focus their activity.
- Ensure that ToRs have clear and focused outcomes (e.g. publications, software/ methodology, datasets, advisory inputs, public outreach, etc.) that demonstrate advances and innovation. A new template for EG resolutions will reflect this.
- Ensure ICES recognizes and values the work of its EGs through an objective self-evaluation that facilitates the uptake of their outcomes. This will also help ICES prioritize, support and defend the ongoing work of EGs.
- Facilitate the identification, uptake and follow up of EG outputs directly into the ICES advisory activities, through a more dynamic, objective-driven management system.
- Re-balance the interactions between the EGs and SCICOM in favour of science strategy issues at the onset and completion of each multi-annual ToR.
- Make the EG portfolio more responsive to future changes in the ICES Science Plan, as well as other scientific priorities.

To achieve these goals, SCICOM has proposed changes to the operations of all Expert Groups. These changes were circulated to the WGFTFB by the Chair early in 2012, and the responses were provided to SCICOM prior to the meeting. WGFTFB responses to each proposed change were reported at the meeting, as follows.

- 1) The terms for all EGs would be fixed at an initial 3-year. Currently, SGs and W/S have fixed duration. WGs have open-ended terms. Renewals could be requested. SGs disappear as a structure as they are effectively an EG with a single term. W/S are not affected by these changes.

Response from WGFTFB: It is not in WG's best interests to have continued existence questioned in a partnership. All discussions regarding the future of WGFTFB should be conducted together with FAO. FAO hosting every third year may interfere with this cycle.

- 2) Terms of Reference (ToRs) for all EGs will be approved by SCICOM at the onset for the full duration of 3 years, instead of annually. New ToRs can be considered in response to ad hoc requests.

Response from WGFTFB: Multiyear ToRs are already being used by WGFTFB through topic groups, but not in synchronization with each other.

- 3) EGs will provide interim, reduced, reports at the end of years 1 and 2 of their appointment, and a final, comprehensive report at the end of year 3, replacing annual reporting.

Response from WGFTFB: The WGFTFB report contains information that is best captured annually (Technological Creep/Advice, progress by topic groups, National reports), and this change would not reduce the reporting burden.

- 4) EGs will self-assess, through a simple questionnaire that identifies and showcases their achievements against original goals. Renewals for further terms are considered by SCICOM based on justification and self-assessments. Previously, EGs were not evaluated systematically.

Response from WGFTFB: It is questioned whether EGs can be the best judges of their own worth, and whether there are EGs that have outlived their usefulness. Also, it is seen as a task for steering groups (SSGs) to determine relevance and effectiveness of EGs.

The ICES-FAO WGFTFB feels strongly that this group is a highly effective and unique expert group that has endured and prospered. The group is well-respected worldwide and broadening its reach globally, with recent progress in connecting to Latin America and Asia. Especially in these early stages of the stronger partnership with FAO, any changes should be carefully considered, as they will set the tone for the relationship and the group's success.

WGFTFB should emphasize its relevance and value through:

- Tangible, useful products, including peer-reviewed original research, review papers, CRRs and others, perhaps by direct reference in a document,
- Relevant and important results within the ICES system, and
- Responses to requests.

7.4 Request on data collection on marine litter during surveys

Thomas Maes of Cefas requested feedback from bottom trawl survey experts in WGFTFB on the potential use of surveys to collect data on marine litter under the EU's Marine Strategy Framework Directive (MSFD). The information requested could also be used on the comments on the new Data Collection Framework, namely on the move towards integrated surveys.

In his view, litter collection under existing fisheries schemes is hindered by the different types of trawls (GOV or Beam trawls), and a non-harmonized approach in litter data collection.

Ideas from the group were sought by e-mail and at the meeting in terms of:

- Possibility of further harmonization between different types of nets used in IBTS (GOV/Beam, net apertures, mesh, codend sizes, ...) or at least an overview of the exact types of net in use across the different parties with similarities and differences.
- Known previous studies where catch percentage is compared between different net types to determine ratios between GOV and Beam trawls.
- Adaptations of fishing gear or surveys to allow better catch/reporting of litter
- Harmonization of different types of cruises delivering information to IBTS (e.g.: trawl time, station planning, ...).
- Advice on implementing the reporting sheet and making sure the same procedures are used on all cruises.
- Evaluating the Standard Operating Procedures: Ease of use? Reporting sheet? Suggestions?
- Future changes which can be implemented to make litter collection easier on their cruises.

- Parameters which can be easily added to the survey without loss of time for primary objectives and cost implications but relevance to marine litter quantities and its distribution (e.g.: storm events, shipping routes, fishing hot spots, water temperature, wind direction, wave heights, ...) .
- Personal Opinions and relevant experiences in relation to marine litter during IBTS cruises.
- Any Ideas or requests for better integration? Problems they foresee?
- AOB in relation to Marine Litter.

Ingeborg de Boois (from IMARES, The Netherlands) has sent in a written response, stating that:

- Data are collected on some NL surveys, with space limiting on others.
- Data collection parameters are still uncertain under MSFD, so we don't know who wants what information. Parameters may vary by nation.
- Uniform, easy-to-handle data sheets.
- Clear litter characterizations.
- Central data storage location.
- Strange to modify any gears to improve litter registration, at least when using the current surveys as a source of information.
- If a new survey is going to be designed, then it would be good to think about this issue.

ICES WGISUR (chaired by Dave Reid) has discussed the optimal ecosystem survey and a report will be made available soon.

Jens-Otto Krakstad (IMR, Norway) has informed WGFTFB that the Nansen program along the west coast of Africa has recently initiated routine collection of information on marine litter. For the moment they are collecting very basic information, only number of items per trawl and type of litter in broad categories, plastic, metal, fishing gear, other litter. Keeping the registration simple has been a goal as every extra sampling activity one undertakes on-board is costly.

7.5 ICES Advice on Data Collection Framework

ICES draft advice, described below, on the Data Collection Framework (DCF) was presented to the group for any comment.

Sampling should be on a coordinated regional basis rather than on a national basis, including:

- Designing data collection from the outset to most efficiently cover fisheries activities and fisheries ecosystem impacts on a marine ecoregion scale.
- Further development and maintenance of regional databases holding the DCF data to give end-users effective access to the data while applying the access rules of the DCF.
- Sampling should be on a coordinated regional basis rather than on a national basis, including:
 - Designing data collection from the outset to most efficiently cover fisheries activities and fisheries ecosystem impacts on a marine ecoregion scale.

- Further development and maintenance of regional databases holding the DCF data to give end-users effective access to the data while applying the access rules of the DCF.

Further integrated data collection in order to address both fishery impacts on marine ecosystems and an ecosystem approach to marine management.

Integrated data needed to assess the ecosystem impacts of fisheries including data on bycatches of all biota, discards, impacts on foodwebs, biodiversity and population genetics and on habitats.

Integrated data collection in order to support an ecosystem approach beyond fisheries, including data collection requirements that will be needed in order to demonstrate compliance with the Marine Strategy Framework Directive and the Habitats Directive.

This should specifically be reflected in a move towards multi-functional surveys and monitoring which collect integrated data regarding fisheries and the environment.

Improve end-user access to data as needed for assessments and to respond to policy needs. This means specifically that data must be available with high spatial resolution, which may imply on single vessel /single haul basis.

Currently the exception clause in Art 20(4) of Regulation (EC) No 199/2008 is used by those responding to requests for data to prevent access to detailed data in Art 18 of the same Regulation and, in practice, detailed data are not available. This undermines the ability to provide scientific advice on ecosystem impacts (DCF indicator 5, 6, 7 of Annex XIII of Commission Decision 2010/93) and on spatial regulation of fisheries activities as for instance implied in the habitats directive. If exception clauses are introduced, they must be associated with clear delimitations of their applicability.

The data collection programmes should be flexible so that new data types can be included in future without Member States incurring financial penalties. Research vessel survey resource in Europe is finite, and the collection of new data for European policies such as the Marine Strategy Framework Directive will require less traditional data being collected. Such flexibility must be built into the new DCF.

7.6 Nominations for ICES prizes

The group was asked to consider:

- Nominations for the prestigious ICES Prix d'Excellence and Outstanding Achievement Awards, are being solicited for awards to be made in Bergen at the ASC 2012. The deadline for nominations is 1 June 2012.
- The Awards, nomination procedures, and deadlines are fully described on the ICES website (<http://www.ices.dk/iceswork/awards.asp>).
- Outstanding Achievement: This award recognizes a person who has made substantial and outstanding contributions to ICES in the broad field of marine science or management over at least a 15-yr period. The award can be made on an annual basis.
- Prix d'Excellence: This award recognizes a scientist who has made extraordinary contributions to marine science. The person need not be an active contributor to ICES or its activities. The award can be made once every three years or, under extraordinary circumstances, in other years. An award is anticipated in 2011.

- Persons previously nominated will be fully eligible for consideration during evaluation of nominees in 2012. These nominations must be updated, however, with at least a communication to the Awards Committee requesting such consideration.

7.7 Other comments

Further points mentioned were:

- Develop new topic group, study group, workshop, and ASC 2012 theme session proposals for Friday.
- National reports ASAP!
- Advice Questionnaires are to be filled-in!
- Use the SharePoint site to upload documents.

8 Report from FAO (Petri Suuronen)

FAO informed and updated the ICES WGFTFB members of FAO's work priorities in fishing technology and other fields closely related to the work of the Working Group. The list of activities shown included the status of the following issues:

- International Guidelines on Bycatch Management and Reduction of Discards.
- FAO driven projects on trawl fisheries bycatch management.
- Areas Beyond National Jurisdiction (ABNJ) projects – Tuna, Deep Sea.
- A practical guide on comparative testing of BRDs.
- Low-Impact and Fuel-Efficient (LIFE) fishing.
- GHG reduction in fisheries.
- Fisher safety at sea (<http://www.safety-for-fishermen.org>).
- Fish Aggregating Devices (FADs).
- FAO Technical Guidelines for MPAs.
- Stop IUU fishing award.
- FAO Gear Catalogue – update.
- Committee on Fisheries (COFI 30th).

FAO International Guidelines on Bycatch Management and Reduction of Discards were adopted by the Committee on Fisheries (COFI) in 2011. The Guidelines present a general framework for effective bycatch management. FAO is currently promoting the implementation of these guidelines. The objectives and expected outcomes of some regional FAO-facilitated bycatch projects, such as REBYC-II CTI, were presented. This project aims at improved bycatch management in SE-Asian multispecies bottom/shrimp trawl fisheries. The overarching goal is the sustainable use of fisheries resources and healthier marine ecosystems. The expected outcomes of the project include (i) agreed trawl bycatch management plans, (ii) improved measures and techniques to reduce problematic bycatch, (iii) better use of residual bycatch, (iv) critical barriers for executing responsible fishing addressed and (v) effective incentives identified for trawl operators. The project is funded by the Global Environmental Facility (GEF) and the participating countries (Indonesia, Philippines, Thailand, Vietnam, and Papua New Guinea). The Southeast Asian Fisheries Development Center (SEAFDEC) is the regional project facilitation unit. The WG was in-

formed of a soon-to-be-published FAO Practical Guide on Comparative Testing of Bycatch Reduction Devices in Tropical Shrimp-trawl Fisheries (author Steve Eayrs).

Areas Beyond National Jurisdiction (ABNJ) cover more than 60% of the world's ocean's surface. Management issues for these areas are complex but increasingly important for fisheries. Challenges include increased pelagic fishing for highly migratory species, lack of comprehensive legal instruments and normal management options, extensive marine debris and pollution, and high impacts on biodiversity. Two large ABNJ projects under preparation at the lead of FAO were presented briefly (ABNJ Tuna and Deep-sea). Both of these projects include a bycatch component.

The WG was updated on a FAO driven approach on Low Impact and Fuel Efficient (LIFE) fishing practices. An introduction into the topic was published in early 2012 in *Fisheries Research*. Case studies will be looked at (with socio-economics involved) and the theme will likely be one of the themes for FTFB 2013 mini-symposium. The WG was informed that an expert workshop on GHG emission strategies in fisheries was held in January 2012 at FAO. According to preliminary analysis, fishing vessels are the largest GHG emitters in the sector, followed by processing plants, with transportation at a lower scale. A supply chain approach can identify hot spots for GHG emissions. The second workshop will produce practical guidance for fishing industry. It was noted that FAO is involved in the development and practical guidelines of Fish Aggregation Devices (FADs) for small-scale fisheries. It was also noted that the new FAO Gear Catalogue is at the final stage but still needs approval of the Coordination Working Party in Fisheries Statistics.

FAO has recently published Technical Guidelines for Marine Protected Areas (MPAs) and Fisheries. The guidelines provide guidance on implementation of MPAs when one of the primary objectives is related to fisheries management. The WG was also informed that IUU-fishing continues to be a major problem in world fisheries. A Stop IUU Fishing Award competition will be issued in July 2012. Selection criteria are effectiveness, innovativeness, and feasibility.

The WG was informed that the Committee on Fisheries (COFI) will have its 30th meeting in July 2012 at FAO HQ in Rome. COFI meets every two years to among other subjects monitor the world fisheries situation, discuss emerging international issues, agree on binding and voluntary agreements, examine and evaluate FAO work on fisheries, and agree on FAO's program of work. COFI offers a platform to INGOs, IGOs and industry representatives to communicate with governmental authorities in charge of fisheries. It is an excellent opportunity to foster cooperation between various stakeholders. Total attendance at the COFI meeting has in recent years been some 500–600 persons.

According to the recent agreement between FAO and ICES, FAO will host the WGFTFB meeting every 3rd year at a location of FAO's choosing. The 2013 WGFTFB meeting will be the first meeting hosted by FAO. FAO is currently exploring two options for the venue: Bangkok, Thailand and FAO HQ in Rome, Italy (other options are still possible). The meeting will consist of issues that cross-cut both FAO and ICES interests. Part of the meeting will be organized as thematic "mini symposiums". The structure, duration and preparation of these thematic mini symposiums, however, are still largely open for discussion. A list of possible topics was shown to stimulate the discussion. Input ideas were requested from this group, with suggestions for conveners latest by early September 2012. It was stressed that during the 2013 WGFTFB meeting time will be allowed also for continuation of the more traditional "ICES work". FAO will give special consideration to the attendance by developing

States and non-ICES countries. It was noted during discussion that meetings outside ICES countries likely create funding challenges for many participants from the ICES area but might attract new participation, for instance from Asia and Latin America.

Discussion

For the 2013 WGFTFB meeting two options for the venue were considered: Bangkok, or Rome. Bangkok would provide the advantage that it is also possible to attract workers from outside ICES, *e.g.* from Asia, and Latin America, which would enhance WGFTFB's global perspective. The question was raised whether the meeting should then be held in a multi-lingual format. The meeting may be organized as mini-symposiums, with room for presenting traditional ICES-work. Input ideas were requested from this group, with suggestions for conveners by September 2012. A plea was made to focus on Light Impact Fuel Efficient (LIFE) fisheries. A list of possible topics was discussed. The procedure of decision in ICES runs through the ASC in September. There might be a problem concerning funding opportunities for some participants. Although remote places might attract new participation, *e.g.* from scientists working with artificial light in fisheries, the economic situation at present with budgets likely to get cut (in Europe at least) may deter participants from the ICES-areas to come. Input for ideas on topics is welcomed.

9 Presentation of Expert Group reports

9.1 Report from the Study Group on Turned 90° Codend Selectivity (SGTCOD; Bent Herrmann)

The ICES Study Group on Turned 90° Codend Selectivity, focusing on Baltic Cod Selectivity (SGTCOD) was planned to run for 3 years (2009–2011), extended to 2012 by consent of ICES. The SGTCOD 2012 meeting will take place 23–26 October in Rostock, Germany. The Study Group will have the following terms of reference for the 2012 meeting:

- Evaluate the effect of turning diamond netting by 90° (T90) on codend selectivity.
- Improve knowledge of the size selection processes in T90 codends compared to T0 codends (normal direction of diamond netting).
- Attempt to quantify the magnitude of the effects of different factors (construction, generic netting properties, stock specific morphology, catch composition).
- Develop a guide on T90 codend constructions with respect to size selection properties and optimal construction.
- To compare the selective properties T90 codends with those of the other legal designs targeting Baltic cod.
- Review available data on fish survival and in particular cod escaping from T90 codends.

During the first three years of SGTCOD, scientists from Germany, Poland, Denmark, Norway, Iceland, Sweden, France, Italy, Spain, Turkey and Russia have participated in the SGTCOD meetings and have provided information and/or contributed with additional work to the group. A number of new selectivity trials have been conducted mainly by Germany with participation of also other SGTCOD members. Additional new selectivity data have also been provided from Denmark, Norway,

Turkey and Iceland which helps establish the understanding of the basic principles of how T90 selectivity works. Data on fish morphology have been collected for main species in Baltic Sea and is currently being analysed.

Concrete achievements of the SGT COD include:

- Assessment of the influence of number of meshes around in the codend on size selectivity in T0 (standard diamond mesh codend) and T90 codends. The study concludes that the number of meshes around needs to be considered which is also done in the current legislation for use of T90 in Baltic Sea trawl fishery. The study is published as:

Wienbeck, H., Herrmann, B., Moderhak, W., and Stepputtis, D. (2011). Effect of netting direction and number of meshes around on size selection in the codend for Baltic cod (*Gadus morhua*). *Fisheries Research*, 109(1), 80–88.

- Assessment of the influence of the codend twine-thickness on size selectivity for T0 and T90 codends on Baltic cod. A German research cruise was conducted testing 12 different designs in 43 hauls with more than 64,000 cod caught and measured. The study concluded: I) single twine provides better selectivity (higher L50 values) compared to double twine for both T0 and T90 codends; II) single T90 is preferable as its size selection is less dependent on twine diameter than for the other constructions; III) double twine T90 has no advantage compared to single twine T0. Currently work is ongoing with the aim to document this study in a scientific paper.

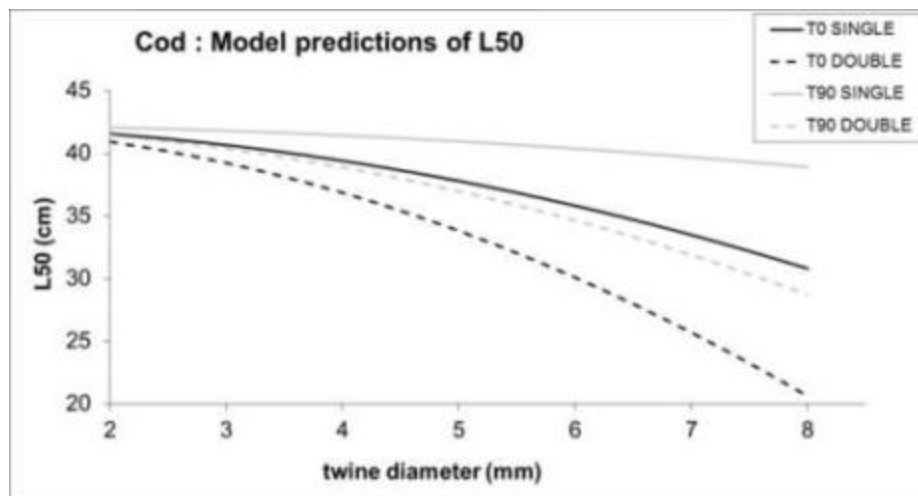


Figure 1. Prediction of L50 for cod as a function of twine thickness from model studies.

- Investigation and comparison of the escapement patterns of Baltic cod from T90 and BACOMA codends. During a German research cruise it was investigated to which extent cod of different sizes did escape during towing at the seabed and during haul-back operation of the fishing gear to the surface. Because the time of escapement might influence the survival likelihood it is of interest to assess whether or not there is significant difference in the escapement patterns of Baltic cod from T90 codends and the other legal alternative the BACOMA codend. The study did conclude (based on the population structure available during the cruise): I) that more than 30% percent of cod escaping did so first during the haul-back

operation; II) except for a few length classes above 50 cm no significant difference in the escapement likelihood is detected between the two legal codend types.

Based on the progress so far it is expected that SGTCOD will be able to fulfil most of the terms of reference to a satisfactory level.

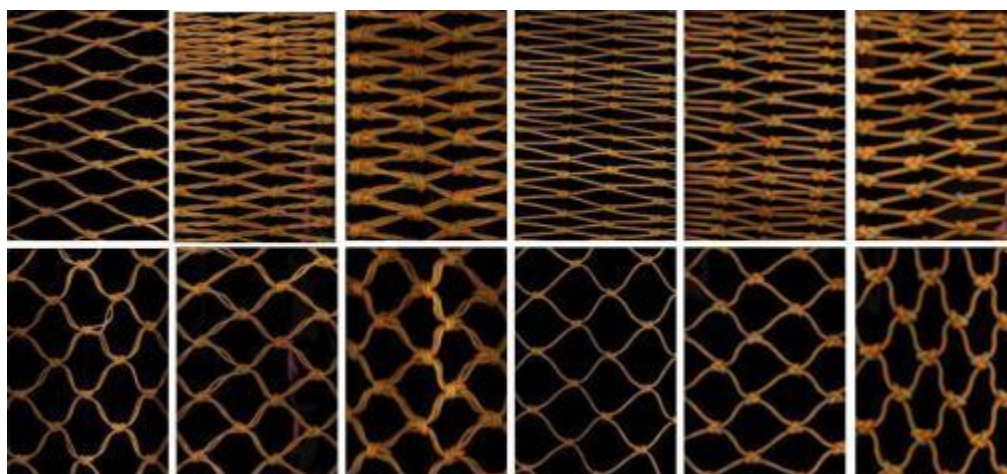


Figure 2. Codends tested on FRV "Solea" (March 2011).

Discussion

Tow duration was about 2–2.5 hrs, in normal commercial practice usually around 5 hrs. Catch sizes were 2000 kg on average. The Selection Range (SR) needs to be looked at too, not only L50. T90 single twine 4 mm has a lower SR than the BACOMA codend. The fishing industry will be addressed in a workshop in May 2012 to learn their views, and draft a proposal for solutions. The losses shown might frighten them off. What to choose for the same breaking strength? Then thinner double twine might be the better choice. Do twine configurations maintain their shape? T90 knots might stretch deteriorating selectivity. This issue still needs to be investigated in more detail through an aging study. The question is raised whether we should use commercially fished codends instead of brand new ones. Experiments addressing this issue were planned, but not carried out yet. Scientific publications will be written on this work. Another relevant point mentioned is whether research vessels (RVs) do deliver representative data for commercial vessels (CVs).

9.2 Report from Study Group on Electrical Trawling (SGELECTRA; Bob van Marlen)

The Study Group on Electrical Trawling (SGELECTRA), chaired by Bob van Marlen, the Netherlands and Bart Verschueren, Belgium, met in Lorient, France, 21–22 April 2012 to:

- a) Improve knowledge of the effects of Electrical Fishing on the marine environment (reduction of bycatch, impact on bottom habitat, impact on marine fauna, energy saving and climate related issues), in view of current technical developments on electrical fishing and emphasis on the relationship of pulse characteristics (power, voltage, pulse shape) and thresholds in terms of effects on fish and other organisms (mortality, injury, behavioural changes);

- b) Evaluate the effect of a wide introduction of electric fishing, with respect to the economic impact, the ecosystem impact, the energy consumption and the population dynamics of selected species;
- c) Consider whether limits can be set on these characteristics to avoid unwanted effects (e.g. unwanted and uncontrolled growth on catch efficiency, unwanted ecosystem effects) once such systems are allowed and used at wider scale.

SGELECTRA was also asked to report by 30 June 2012 (via SSGESST) for the attention of SCICOM and ACOM.

A total of 7 participants attended from Netherlands, Belgium, Germany, Scotland, and France. The meeting began with a short presentation on the history of research of pulse trawling (on flatfish), and the ICES Advice on Pulse Trawling on flatfish of 2006 and 2009. Following the ICES Advice of 2009 further studies were carried out by IMARES.

New research activities of IMARES, IJmuiden, The Netherlands, were presented and discussed, namely: a catch comparison in May 2011 on two pulse trawl vessels and one conventional tickler chain beam trawl boat fishing side-by-side, further analysis of spinal damage in cod (*Gadus morhua* L.) in 2010 and 2011, reference measurements of field strength *in situ* in 2011 and the result of an effect prognosis, using the model developed by Piet *et al.*, 2009 and the data from the catch comparison.

A presentation was also given about the development of a pulse trawl (called the "Hovercran") for the brown shrimp (*Crangon crangon* L.) fishery by ILVO, Ostend in Belgium, and work to be carried out by two PhD students from the University of Ghent in cooperation with ILVO. This work has been given follow-up in The Netherlands on three commercial vessels, and a project on shrimp fishery using the "Hovercran" in Germany on a commercial boat is about to begin.

In addition a report was given on the razor clam (*Ensis*) fishery in Scotland in which electrical stimulation is used. In addition a new problem was mentioned related to electrical stimuli of heavy power, i.e. the production of chlorine (it and its derivatives are toxic to marine organisms and soluble in seawater) due to electrolytic reactions.

Discussions in the Netherlands Control and Enforcement Group and draft Procedure for Control and Enforcement were presented and the draft text in English improved.

A recent report by STECF was discussed and comments given on its contents.

The reviewing experts concluded that:

- It was acknowledged that as a result of the studies for ICES more information on the effects is now available than 6 years ago, e.g. real numbers on damages in cod in the catches, also dependence of damages on size classes, the effect on sharks, and invertebrates.
- Further long-term investigations be undertaken.
- The pros and cons of each system be taken into account.
- The views of SGELECTRA on pulse trawling are still under development.

SGELECTRA recommended continuing to work, and to meet in autumn 2013 with Terms of Reference given in Annex 2 of their Report. The following list gives items for further work, *i.e.*:

- Carry out further analysis of the catch comparison data of May 2011, and prognosis of effects on major target species using the Piet *et al.*, 2009 model.
- Investigate the effect of pulses on the electro-receptor organs of elasmobranchs (catshark and thornback ray), and determine the catch rates of these fish in beam trawls using the Hovercran pulse.
- Report on the trials on the Hovercran developed in the Dutch fleet.
- Investigate the effect of the electrical stimulation on eggs, larvae and juveniles of sandworm, shrimp, cod and sole, using the Hovercran and the flatfish type of pulse.
- Carry out research on pulse suitable to generate the startle response in sole.
- Investigate aspects of control and enforcement and develop acceptable limits to be set in any future regulation, and consider a wider coverage in Europe, e.g. participation by UK, France, and Germany.
- Harmonize sampling and data collection methods.
- Trials and data collection and analyses on the Hovercran type of Crangon pulse gears.
- Continue monitoring catches onboard commercial pulse trawl vessels in 2012.
- Further consider the development of *ensis* fishery in the UK.

Discussion

Will effect on cod be acceptable, as this is not to be expected? Small fish are not affected, and the proportion affected in the catch is relatively low, and it is an ethical and ecosystem management question what to catch and what to save. Is there not a vested interest? Yes there are investments, but under derogation and we look at it objectively. It is difficult to predict whether the existing ban in the EU can be lifted. The complexity of the work and new activities that will start was noted. The SG has addressed all three ToRs, but feels that new fundamental research, e.g. by the two PhD students of the University of Ghent, Belgium will give more insight in the coming years. In addition there are more countries involved than a few years ago, and there are several applications, i.e. for flatfish, brown shrimps and razor clams. Therefore it is not to be expected that all questions will be answered soon. On the other hand a lot has been learned since 2006 when ICES posed its first three questions. It should also be noted that recently the EU Scientific Technical and Economic Committee of Fisheries (STECF) issued a report on pulse trawling this month.

10 ToR A: Incorporation of Fishing Technology Issues/Expertise into Management Advice (Mike Pol and Dominic Rihan)

10.1 General Overview

This ToR was introduced prior to the meeting via e-mail and at plenary by the chair. The background for the ToR was re-iterated. ICES advice is increasingly holistic in nature, including information on the influence and effects of human activities on the marine ecosystem. This information should include responses and adaptations to changes in regulatory frameworks by fishers. In response to this need, WGFTFB initiated a ToR in 2005 to collect data and information that was appropriate to fisheries and ecosystem based advice. In 2006, the FAO-ICES WGFTFB was formally requested by the Advisory Committee on Fisheries Management (ACFM) to provide such information and to submit it to the appropriate Assessment Working Group. This type of information is important at both international and national levels and demonstrates that the WG has an important role to play in this advice and that our expertise is highly valued. Since 2009 this information has been included as an Annex to several stock assessment reports e.g. WGNSSK, WGCSE and WGHMM, although the issue of the appropriate timing for the provision of this information to the assessment working groups remains unresolved.

10.2 Terms of Reference

WGFTFB should explore the means by which it can best provide appropriate information for Assessment Working Groups, ACOM and other management bodies such as GFCM in fishery and ecosystem based advice. This exploration will include the information required for fisheries based forecasts, technological creep and changes in fishing practices, implementation of regulations and other fleet adaptations, ecosystem effects of fishing and potential mitigation measures. The information focuses on, but is not limited to, areas for which ICES provide stock advice.

10.3 General issues

The conveners issued a questionnaire to all the WGFTFB members (see Annex 5: WGFTFB information for other ICES expert groups and questionnaire sent to WGFTFB members). The questionnaire was also available as an online form at: <http://tinyurl.com/3on54sj>. The questionnaire consisted of a series of questions relating to recent observed changes within fleets and also highlighted gear/fleet/fishery related issues that are important but are not currently recognized by Assessment WG's. Where possible, contributors were requested to quantify the information provided or state how the information has been derived e.g. common knowledge, personal observations, discussions with industry etc.

Specifically FTFB members were asked to comment under the following headings:

- Fleet Dynamics.
- Technology Creep.
- Technical Conservation Measures.
- Ecosystem Effects.
- Development of New Fisheries.

Responses to the questionnaire were received from:

- IMARES, Netherlands.
- AZTI, Spain.
- IMR, Norway.
- BIM, Ireland.
- CNR-ISMAR – Italy.
- IMR, Iceland.
- SUAS-IMR, Sweden.

Relevant information from the National Reports of the countries listed and also Marine Scotland, UK and Ifremer, France was also included.

The information provided was collated with the responses reported below, with preceding summaries. Information tailored for individual ICES Expert Groups is given in Annex 5: WGFTFB information for other ICES expert groups and questionnaire sent to WGFTFB members.

Fleet Dynamics

As in the last previous 3–4 years fuel prices were the dominant feature in all countries that affected fleet dynamics. Rising cost were manifested in multiple ways: shifts in gear, modifications to fishing practices, changes in vessel powering. Of particular note is the shift in the Netherlands away from traditional beam trawling to the use of the pulse trawl and the Sum Wing. It is now apparent that within the Netherlands, driven primarily by the cost of fuel, there is huge demand to use the pulse trawl and the number of vessels applying to fish under the 5% derogation far exceeds the number of licences available. Vessels not using the pulse trawl in the Netherlands are finding it increasingly difficult to get financial support from banks on economical (high fuel prices making beam trawling uneconomic) and ecological grounds (beam trawls are portrayed negatively).

A continuing trend was seen in France and Netherlands to convert to Danish seining instead of conventional trawling or beam trawling. Some vessels have completely converted, while some have diversified and have maintained trawling to take advantage of both seining and trawling opportunities. At least two Dutch vessels have been converted to multi-purpose vessels with the capability of both beam trawling and twin-rigging.

In Iceland after several years of low quotas for capelin and blue whiting there has been a large increase in the quota for these species in 2011–2012 which has meant an increase in trawling and purse seining in Iceland. In the capelin fishery this has meant that vessels that were targeting pearlside (*Maurolicous mulleri*) have reverted back to capelin. Catches of pearlside have gone from 46,000 tonnes in 2009 to zero in 2012.

In the Mediterranean over the period 2010–2012 there have been multiple changes in fleet dynamics which have been driven by a combination of EU and national Regulations as well as fuel prices. Changes in the pelagic and dredge fisheries are particularly apparent.

Decommissioning schemes are less in evidence than in previous years although the general trend is for continuing reductions in fleet sizes. There is evidence of fleet renewal in several countries particularly Iceland and Norway and to a lesser extent Ireland. All reported changes related to fleet dynamics are summarized below:

- Over the period 2009–2011 there have been continuing shifts in fleet dynamics observed in the Basque fleet. Effort by this fleet (single and pair-trawlers) has been concentrated in ICES Areas VIIIa,b,d from October to February. From late March and June 50% of the single trawlers (4 of 8 boats) have moved from VIIIa,b,d to Area VI. (Spain (Basque): Implications: Shifts in gears and areas).
- In the Basque pair trawl fleet targeting hake, vessels are tending to make shorter trips, due to low market price. Shorter fishing trips improved the fish freshness and quality. Also, it has been observed that vessels are coordinating their landing times in base ports sequentially during the week, spreading supply over the week rather than concentrating landings on Mondays and Thursdays as was traditional practice. Auctions are being held throughout the week which has the potential to raise the market price of the catch. (Spain (Basque): Implications: Shifts in fishing patterns driven by market requirements).
- There are continued indications that Spanish bottom trawlers have varied their spatial-temporal fishing strategy in order to avoid mackerel in their catches, which can be significant at times. This is because of a reduction in the Spanish mackerel quota in 2011 due to an overshoot of the quota in 2010. (Spain: Implications: Reduced bycatch of mackerel).
- As in 2010 the Basque artisanal fleet operating on tuna (trolling lines) and mackerel (handlines) all year, traditional fishing patterns were spread over 8–9 months with about 3–4 months on mackerel and 4–5 months on tuna. The rest of the year the fleet was tied-up. Reductions in the mackerel quota in 2011 has reduced the mackerel season by 1–2 month season for this species and some boats have started fishing with other gears (longlines, gill-nets) to fill out the year activity. (Spain (Basque): Implications: Shift of effort into other fisheries due to quota restrictions).
- In the period 2010–2012 about 20% (4 from 12 vessels) of the single trawl fleet and the same percentage from the Basque pairtrawler fleet have been decommissioned (1 from 4 pairs) some of these vessels were relatively modern being around 10 years old. (Spain (Basque): Implications: Fleet reductions as a result of decommissioning).
- A sixty day fishing closure for Spanish trawlers operating in NW Iberian waters entered into force in 30 April 2011. This cessation of activities is in addition to the thirty day closure included under the Hake and *Nephrops* recovery plan. Vessels must tie-up for this 60 day period between the date of entry into force and 31 October 2011. It can be divided into 4 periods of 15 days duration each (Spain: Implications: Reduction in fishing effort by Spanish trawler fleet).
- The 5 whitefish trawlers (> 24m) based in Greencastle in the NW Ireland which traditionally have regularly shifted between fishing areas (Area VIa, VIb, VIIb-k) at short notice depending on fishing opportunities have tended to concentrate efforts on their local grounds in VIa due to the price of fuel. Two of the larger of these vessels are finding it increasingly difficult to remain viable given the high operating costs. (Ireland: Implications: Shift in effort back to VIa).
- Effort levels in the Irish TR2 (*Nephrops* vessels) sector in the Irish Sea was exhausted in October 2011 meaning the majority of the fleet, except three vessels using sorting grids, were prevented from fishing in the Irish Sea.

Up to 16 vessels subsequently applied to fish using the sorting grid to gain some level of access to the fishery. This forced tie-up affected up to 40 Irish vessels and was particularly controversial given vessels from Northern Ireland continued to fish unrestricted during this period. (Ireland: Implications: Closure of fishery).

- With the current fuel prices, many Irish vessels have switched from targeting megrim, monkfish and hake to Nephrops to try to reduce operating costs. Some of the larger 20m+ vessels are particularly affected and as a result fishing effort in the Nephrops fisheries in the Smalls, Aran grounds, Porcupine and Labadie Bank will increase. (Ireland: Implications: Shift of effort from mixed demersal species to Nephrops)
- Five Irish whitefish vessels (24m+/700hp+) were granted an exemption from the effort regime in Area VIa (West of Scotland) in 2011. This represents around 95% of the active Irish vessels in this area. This exemption was granted on the basis that these vessels did not fish in an inshore area of the Donegal coast with historically high cod catches. These vessels must use 120mm mesh size and 120mm (9–12m) square mesh panels inside a restricted area inside the so-called "French Line" but can use 100mm+90mm small mesh panel (smp) outside this area. These vessels have been subject to enhanced coverage by scientific observer sampling which has shown an increase in cod catches with several trips observed to have cod catches in excess of 1.5%. This is primarily because of one vessel which has tended to fish in an area more likely to have cod bycatch. On this basis these vessels may lose their effort exemption in 2012 (Ireland: Implications: Inclusion of vessels back under the effort regime).
- Despite high fuel costs and quota and effort restrictions at least 6 modern second-hand vessels have entered the Irish fleet. The largest of these is 23m/580kw freezer vessel. All of these vessels will primarily target Nephrops. (Ireland: Implications: Entry of modern second-hand vessels).
- Two 20m Irish vessels have been tied-up since early 2011 due to discrepancies between their stated and actual engine power. It is likely other Irish vessels will also be tied up due to similar anomalies between actual and reported engine power (Ireland: Implications: Tie-up of vessels).
- It is now apparent that within the Netherlands, driven primarily by the cost of fuel, there is huge demand to use the pulse trawl and the number of vessels applying to fish under the 5% derogation far exceeds the number of licences available. Vessels not using the pulse trawl in the Netherlands are finding it increasingly difficult to get financial support from banks on economical (high fuel prices making beam trawling uneconomic) and ecological grounds (beam trawls are portrayed negatively). A total of 42 licences have been given out by the Dutch Ministry for pulse trawling. The majority of these licences are for flatfish beam trawls although 2–3 vessels are involved in trials to test the Belgium "HOVERCRAN" system. (Netherlands: Implications: Switch from beam trawling to pulse trawling).
- Measures to reduce fuel costs in the Dutch fleet have been continuing since 2008 from 35% (now 50 M€) to 25% in 2009 due to adaptations in gear and operation. Reports show that the use of the SumWing can save up to 300 tonnes of fuel per year per boat (LOA = 40 m), and with the pulse trawl up to 800–1000 tonnes annually. Up to 78 Dutch beam trawlers now used the SumWing with 28 of these using the Pulse/Wing trawl. A further 12 Dutch

registered vessels in the UK, 2 in Germany and 5 in Belgium are also using the Sum Wing with 3 of these using the dual Pulse/Wing. (Netherlands: Implications: Switch to more fuel efficient gear).

- The use of the SumWing, Pulse Trawl and Pulse/Wing beam trawls are reported to have resulted in a shift in grounds in ICES Area IV, and also add fishing time, due to faster hauling speed. This is not well documented but may result in increased a change in effort patters and increased fishing time (Netherlands: Implications: Improved fuel efficiency).
- A recent analysis carried out in the Netherlands has measured the relative changes in catching efficiency between the pulse trawl and the standard beam trawl in numbers caught per hour. This analysis has shown a reduction in catching efficiency for plaice of around 25–30%; for sole 20–25% with a reduction in discards of 55–60% and a reduction in benthos of 35–40%. (Netherlands: Implications: Changes in catching efficiency).
- There are a smaller number of vessels in Belgium, Germany and the UK (Dutch owned) using the pulse trawl. However, the derogation only allows it to be used in the south of the North Sea and this has hindered the uptake of the gear in Belgium as they have only a limited sole quota in this area. (Belgium: Implications: Lower uptake of pulse trawl).
- The shift to Danish/Scottish seining has continued in a number of countries. This is driven by high fuel prices: There are now around 16 Dutch vessels operating in the North and the South North Sea, while there are around 12 French vessels now converted to Danish seining. (France: Implications: Shift from trawling to Seining).
- At least two Dutch beam trawlers have been converted into dual purpose vessels with the capability of fishing with twin-rigs and beam trawls. The idea is to increase the fishing opportunities for these vessels and allow them to switch between fisheries at different time of the year. (Netherlands: Implications: Dual purpose fishing vessels).
- In Norway there has not been any removal of fishing effort through decommissioning but the number of vessels has reduced due to movement of quota from newer and bigger vessels. In particular the medium and larger sized seine net fleets are being renewed. Altogether 3–4 new large white-fish trawlers, 4–5 pursers, 7–9 large seine netters and a large number of coastal vessels have entered the fleet over the period 2010–2012. While not measured it is likely that capacity and effort have increased. (Norway: Implications: Increases in fishing effort).
- After several years of low quotas for capelin and blue whiting there has been a large increase in the quota in 2011–2012 which has meant an increase in trawling and purse seining in Iceland. In the capelin fishery this has meant that vessels that were targeting pearlside (*Maurolicous mulleri*) have reverted to capelin. Catches of pearlside have gone from 46,000 tonnes in 2009 to 18,000 tonnes in 2012 to 9,000 tonnes in 2011 to zero in 2012. (Iceland: Implications: Movement from pearlside to capelin).
- During 2010–2011 26 small vessels, 3 factory ships and 1 trawler have entered the Icelandic fleet. There is no indication of vessels having left the fleet. (Iceland: Implications: Increase in fleet).
- As a result of measures under Regulation (EC) 1967/2006 from June 2010 in the Northern Adriatic Sea the use of towed gears has been prohibited

within 3 nautical miles from the coast while the use of beach-seine and boat seine targeting *Aphia minuta* (Gobiidae) and juveniles of sardine (*Sardina pilchardus*) is prohibited without a specific management plan. This affects a large number of Italian vessels and is shifting effort into other fisheries and other areas (Italy: Implications: Shifts in effort as a result of management changes).

- A derogation to the above measures has been introduced in January 2011 whereby the use of trawlnets between 0.7 and 1.5 nautical miles off the coast (at a depth greater than 50 m) is authorized in the following Regions: Liguria, Sicilia, Calabria. (Italy: Implications: Unknown).
- Following the adoption of an Italian Ministerial decree since 2009 bottom trawlers using twin trawls are obliged to fish one day less a week than single rig trawlers. (Italy: Implications: Reduction in effort using twin-rigs).
- In 2011 some fishing vessels changed their activity from rapido trawl to midwater pelagic trawl and from midwater pelagic trawl to bottom trawl. This is mainly for economic reasons. (Italy: Implications: Shifts in effort between métiers).
- In order to reduce fishing effort, in the last years some local fisheries have voluntarily reduced their fishing time from 5 days (legal limit) to 3.5 days. This is mainly for economic reasons. (Italy: Implications: Reduction in effort).
- Several Italian pairtrawlers have switched to single boat trawling in the central Adriatic to reduce fuel costs, manage their own operating costs independently of another vessel and also allow more freedom to adapt their fishing strategy. (Italy: Implications: Shift from pair trawling to single boat trawling).

Technology Creep

As in previous years there is very little evidence of technology creep. Most changes are related to improving fuel efficiency measures. In the Netherlands and Belgium uptake of the SumWing has increased. The development of fuel efficient trawl designs, off-bottom doors in demersal trawling and the use of Dynex warp seen in 2010 and 2011 seems to have spread to many countries.

There has been some innovative research ongoing in Norway where they have looked at the development of prototypes of catch control devices that could help control the size of the catch and that gently release the excess of fish at the same fishing depth. The working principle of these prototypes is based on a codend that closes and partially detaches from the rest of the trawl when it has been filled with a certain amount of fish. In this way the fish that is still inside the belly of the trawl have the chance to escape unharmed. IMR in Norway have also continued to cooperate with a commercial partner (Scantrol AS) on development of a camera-based system to identify and measure individual fish inside a trawl.

A project in Norway looking at improving the efficiency of longlines particularly for smaller vessels is also reported. One of these projects is looking at better mechanization of coastal longline fisheries, particularly for the large fleet of Spanish vessels that longline for hake and other species.

As in previous years there have been a number of developments in gear design to reduce drag. In Italy there has been adoption of twin-rigging instead of traditional single-rig trawls.

All reports of technological creep are given below:

- There have been repeated attempts by the Basque fleets to reduce operating costs by diversifying into other fisheries but with only limited success. Driven by the reduction in the mackerel quota this has been extended to the trolling and handline fleets that have diversified into longlines and purse-seines fisheries in ICES Area VIIIc.
- A project under the European Fisheries Technology Platform (EFTP) is looking at better mechanization of coastal longline fisheries, particularly for the large fleet of Spanish vessels that longline for hake and other species. The objective is to allow automatic baiting with more heterogeneous bait such as sardines, and shrimp; improve operational efficiency on board and also to adapt automatic systems to handle monofilament line which has been a problem in the past.
- As reported the use of the SumWing and Pulse trawl are widespread now in the Netherlands. This is driven by high fuel costs with reported savings ranging from 10–50% from a combination of the gear and lower towing speeds.
- Since 2010 one large Belgium beam trawler is now using the energy-efficient SumWing as a replacement for standard beam trawl gear. In addition some 25 other beam trawlers are using the SumWing seasonally. Additionally there is growing interest in using the electric pulse trawl among the Belgium beam trawl fleet although none of them are using as yet as they are awaiting authorization to do so from the EU. These changes are driven by high fuel prices.
- There have been continued efforts by many countries to reduce fuel costs through the use of more energy efficient gears. Modifications tested include hydrodynamic/low impact trawl doors, Dynex warps, low drag twines and reductions in the size of trawls used. In addition there have been changes in fishing operations through slower steaming to and from grounds, fishing closer to home ports and other fuel saving measures. The actual impacts on fishing effort are difficult to predict but this is likely to be a continuing trend. However, as a result of one project in France (EF-FICHALUT) an energy efficient trawl has been developed and is now being used by 15 whitefish trawls. The anticipated annual savings from these 15 vessels is estimated at €800,000 per year.
- IMR continues to cooperate with a commercial partner (Scantrol AS) on development of a camera-based system to identify and measure individual fish inside a trawl. Preliminary results indicate lengths estimated using the camera system are within 5–10% of manually measured lengths. The system has the potential to be a useful tool to verify size and species stratification by depth during acoustic surveys. A new, more compact, system capable of operating at up to 2000 m depth is being readied for field trials in May and software development to further automate image analysis is underway.
- Semi-pelagic trawls for targeting cod and for saithe have been successfully developed and introduced in the Norwegian fishery. The most successful

trawl is designed with hexagonal front part meshes and rigged with pelagic trawls off bottom. Better efficiency, less fuel consumption and reduced bottom impact are reported, but currently not quantified.

- Research in Norway is looking at the development of prototypes of catch control devices that could help controlling the size of the catch and that gently release the excess of fish at the same fishing depth. The working principle of these prototypes is based on a codend that closes and partially detaches from the rest of the trawl when it has been filled with a certain amount of fish. In this way the fish that is still inside the belly of the trawl have the chance to escape unharmed. Two prototypes, each having a different release mechanism, were developed and tested at sea in April 2011 and March 2012 giving encouraging good results.
- Work has begun in Norway to increase the landings of live cod for buffer storage and on-growing, as well as to include small vessels (< 15m) in this fishery using the Canadian pair seining technique. A pilot study using a normal bottom seine for pelagic pair seining for haddock gave interesting results. Experiments with pelagic pair seining as well as catch limiting devices for seine nets will continue in 2012/2013.
- Up to 12 of the larger seiners in Norway have been converted to freezing at sea. These vessels are trying to target haddock with minimum bycatch of cod to prolong the fishery for haddock and avoid the fishery being closed due to a lack of cod quota.
- Up to 10 vessels in the Icelandic fleet have switched to pair trawling for mackerel and herring from purse seining as this method is felt to be more efficient at catching mackerel in particular.
- Around 30 Icelandic vessels are using bottom trawls constructed in T90° net, but with ordinary diamond mesh codends. The reason is to reduce fuel costs and give better durability. Changes in catchability have not been quantified, but fishers believe anecdotally there is increasing catch with these trawls.
- Some Icelandic bottom trawlers and many pelagic trawlers are using Dynex rope warps and many and increasing numbers of pelagic trawlers. An increasing number of bottom trawlers are also switching from using bottom trawls doors to using semi pelagic trawl doors with weights between doors and wing ends. Reason is saving fuel (~10%) and increased durability.
- Up to 10 vessels in the Icelandic fleet have switched to pair trawling for mackerel and herring from purse seining as this method is felt to be more efficient at catching mackerel in particular.
- In the last 3–4 years some Italian bottom trawlers of the central-northern Adriatic, switched their activity from single to twin-rig trawling (named by the Italian fishers: “Rete gemella”). The main characteristic of the twin-rig are four-panel trawls with small or large lateral panels (named Americana trawl, in Italian). These nets also have large meshes in the wing section and are manufactured in Raschel knotless-PA and knotted-PE netting. The nets are designed to have increased vertical and horizontal openings are thought to be highly efficient.

- Some Italian fishing vessels using the rapido trawl (multi-rig trawl) have decreased the width of the beam from 4 to 3–3.5 m in order to decrease bottom contact and fuel consumption

Technical Conservation Measures

Uptake of selective gears continues to be limited and driven primarily by legislation. Interesting developments include the SELTRA used in Denmark and also tested in Ireland and also the Flip-flap trawl developed in the UK. Both of these devices are designed to reduce cod catches in demersal fisheries.

There have been two developments that have looked at improving the survival of discarded fish. The Dutch shipyard Maaskant are developing an on board separator system to sort out debris and benthic organisms before they affect the catch. The objective of this system is to improve the survival rate of discarded flatfish. In Norway in cooperation with the fishing industry, different parts of the end of the purse-seine (“bunt”) are now being modified; mostly to allow pelagic fish can be slipped from purse-seine easily and quickly in case of too big catches or due to wrong size or quality.

Specific examples illustrating the development and uptake of selective gears or strategies follow:

- Up to 11 Irish vessels (~16–20m/350–500kw) are now voluntarily using the “Swedish” sorting grid in the Nephrops fisheries in the Irish Sea (Area VIIa) although there is no real restriction in days at sea for these vessels following the outcome of the December Council when the baseline efforts were re-aligned. These vessels are exempt or in the process of being exempted from the effort restrictions currently in force in this area. Continued observations carried out show cod catches with the grid to be consistently less than 0.1% per trip and with Nephrops making up more than 95% of the catches with the grids. Up to 30% of the fleet working in the Irish Sea is now using grids.
- Trials in Ireland with the Danish style SELTRA trawl with a large mesh square mesh panel installed in a 4-panel section laced 4m from the codend have shown that reductions in 70% or more in cod catches can be achieved. Similarly testing with a semi-flexible grid in the Nephrops fishery in the Irish Sea have shown this device is as effective as the standard rigid sorting grids currently being used in these fisheries
- Annually since 2009 daily or weekly quotas (depending on the fishery) have been introduced by the fishers in the Basque mackerel fishery (handliners and purse-seiners) and in the anchovy fishery (purse-seiners). These initiatives come from the fishers and are designed to stabilize or increase first sell price
- French vessels have been involved in ongoing trials in the Bay of Biscay in the Nephrops fishery, primarily to improve escapement of juvenile hake and Nephrops selectivity. Devices such as square mesh cylinders, flexible grids, square mesh panels and a combination of the devices have been tested and the results show reductions in hake discards of between 20–40% Trials have been ongoing in France in the English Channel and North Sea on cod and whiting selective devices (large mesh “eliminator” trawls, flexible grids – SELECMER and SELECCAB project). There have also been trials to test a system of real-time closures to protect cod stocks in the

North Sea. Results have been highly variable and the reductions in marketable catches remain a barrier to uptake.

- The Dutch government closed the Botany Gut in December 2011 and 2011 for three months to all trawling to protect cod. The Nephrops fishers have looked for an exemption from this closure on the basis of low cod impact although observer data suggest catches of 2–5/hour. Pilot studies will be carried out in 2012 to test selective gears to reduce cod catches.
- At the Dutch Shipyard, Maaskant are developing an on board separator system to sort out debris and benthic organisms before they affect the catch. The objective of this system is to improve the survival rate of discarded flatfish. Trials will be carried out during 2012 and 2013.
- In Sweden the use of rigid sorting grids has continued to increase in the Skagerrak and Kattegat. In Skagerrak the use of sorting grid has increased from 50% 2009 to 53% 2010 of total TR2 effort. The TR2 effort is by far the most important gear category in both Skagerrak and Kattegat constituting 80–90% of total effort. Almost 100% have opted to use this device due primarily to national legislation allocating 50% of the total Nephrops quota to grid vessels
- Extensive testing has been carried out in the North Sea by the UK (Scotland) with a new design of trawl called the Flip-flap netting grid (FFG) which has been developed by a Scottish netmaker for reducing cod catches in the Nephrops fishery. The results show a large and significant decrease in the number of the three main whitefish species retained by the FFG gear. The reductions by weight of cod, haddock and whiting were 73, 67 and 82% respectively. There are indications that will be introduced as a regulated gear across the Scottish fleet during 2012.
- Trials with sorting grids in the Norway pout fishery were completed in 2011, with further tests of flexible grid designs. In 2011 grids with a 40mm bar spacing were made mandatory for Norwegian vessels on the basis of these and earlier trials for blue whiting and Norway pout in the Barents Sea. From mid-2013 all vessels will have to use in these small mesh fisheries in the Norwegian Economic Zone in the North Sea.
- Experiments from the North Sea carried out by Denmark during 2011 have indicated that 50% of Nephrops above MLS are lost through the codend in nominal 120 mm codends used in the North Sea indicated a general increase in mesh size is not applicable in this fishery. (Denmark: Implications: Loss of marketable catch)
- In July 2011 Denmark introduced a mandatory regulation requiring the use of the SELTRA trawl in the demersal fisheries in the Kattegat. This selective device comprises a 180mm square mesh panel or 270mm diamond mesh panel contained in a 4 panel section laced 4m from the codend. This on the basis of trials with this device which showed very good reductions in cod catches. The L50 for the 180mm panel is around 64cm.
- A combined grid device that releases undersized fish and small sized shrimp is being developed in Norway and is being used voluntarily by some vessels fishing shrimp in the Oslofjord.
- Full-scale experiments to assess the selectivity of different selection devices have been carried out on board Norwegian vessels in 2010 and 2011. The results showed that the selectivity of a 138 mm T90-codend and that of a

codend with 130 mm exit windows gives stable and encouraging good selection in midwater trawling for cod. Both codends proved to be effective to sort out small fish under extremely high catch rates of fish (up to 5 tons of fish per minute). Both caught on average less than 2% of undersized fish in areas which had up to 32% of undersized fish. A 55mm sorting grid showed capacity problems at high catch rates.

- Some Norwegian seine net vessels are using 180mm square mesh codends to release all cod below 2.5 kg headed and gutted. The current minimum mesh size is 125mm. This reflects the requirements of the current market requirements. (Norway: Implications: Voluntary increase in selectivity).
- In Iceland two vessels are testing trawls constructed with horizontal separating panels and two codends. The aim is to improve species selectivity and separating species such as Greenland halibut and redfish from cod and haddock. This work will continue in late June this year.
- There have been closed areas introduced inside several fjords in Iceland for seine nets which have affected a number of smaller vessels. The reasons for these closures are based on ecosystem impacts but the fishers strongly dispute this, claiming such gear to be extremely ecosystem friendly. In addition a ban on directed fisheries for halibut has been introduced that has affecting a number of Icelandic longliners.
- Gear technologists, commercial trawl designers and researchers responsible for pelagic fish stock assessment in Norway, Iceland and Faroe Island have agreed on a common design of a pelagic trawl, and how it should be operated during surveys for the mackerel stock in the Norwegian Sea.
- In 2011 work in Norway continued on methods to get samples of purse-seine caught fish on deck in an early stage in the purse seining process, and well before crowding. Net pockets, both natural and pockets sewn onto the net wall of the purse-seine gave samples, but not on a regular basis. An extreme pocket with an opening area of five by five meter of transparent polyamide netting was thought to fake a hole in the net wall, but video observation demonstrated that the herring did not interpret this "invisible" netting as a hole. In cooperation with the fishing industry, different parts of the end of the purse-seine ("bunt") are now being modified; mostly to secure that pelagic fish easily can be slipped from purse-seine in case of too big catches or due to wrong size or quality. Well proven techniques from the days of live fishing and storage of sprat and mackerel is being revived and incorporated in the purse-seine used for pelagic species.
- Under a French project target-strength measurements for anchovy and sardine have been collected using a towed body "EROC" and an open pelagic trawl termed "ENROL". Before these measurements no accurate target strength values existed for these species.
- In order to manage the newly developed boarfish fishery in addition to the TAC, Ireland has introduced seasonal closures; from September 1-October 31 ICES (area VIIg) to protect herring feeding and prespawning aggregations and from 15 March – 31 August where mackerel are frequently encountered as a large bycatch. A catch rule ceiling of 5% bycatch was also implemented within the fishery where boarfish are taken with other TAC controlled species.

Ecosystem Effects

Discarding due to quota closures was especially noted in Ireland and Spain. Shifts in discarding rates were linked to population changes in Ireland and France. Responses relating to discarding:

- Due to combination of low prices and quota restrictions many Irish vessels (both gillnetters and trawlers) are discarding marketable hake < 60cm.
- Discarding of juvenile haddock and whiting has been very high in the Celtic Sea in quarters 3 and 4 of 2011 and quarter 1 of 2012. This is due to very large year-classes of these species coming through into the fishery. There are reports of boats catching 2–3 tonnes to every 1 tonne retained. Attempts have been made in Ireland to introduce incentives for fishers to take remedial methods by offering extra quota for vessels signing up to using more selective gears. Some positive steps have been taken in relation to some of the Nephrops fleet but other vessels (particularly the seiners) are more reluctant to improve the selectivity of their gears on the basis that losses of marketable fish will be too high.
- During 2011 and 2012 national regulations have prohibited all catches of mackerel catch to all the national fleets until the 15th of February. The trawl fleet operating in ICES VIIIc and usually fishing mackerel at the beginning of the year were subsequently obliged to discard large quantities of mackerel because in that season mackerel is abundant in the areas where this fleet operates.
- Uptake of the Swedish cod and haddock quotas in the Skagerrak have been high in the first two quarters of 2012 (between 55–70%) raising fears that the fisheries will be closed early in the year leading to discarding.
- A recent analysis of Icelandic catch data has indicated trends in discarding of cod and haddock in the longline, gillnet, seine net and trawl fisheries over the period 2001–2010. For cod discarding has been between 0.5–2%, while for haddock has been between 1–5%.

A number of gear modifications have been tested and in some cases are being used to reduce the bottom impact of towed gears. As reported under Technical Creep there has also been considerable testing of trawl doors rigged to fish off-bottom, primarily driven by fuel prices. Both initiatives potentially have benefits in respect of reduced bottom impact. Specific examples:

- A modified scallop dredge (N-VIRO) was tested against a standard tooth bar dredge on the southeast and west coast of Ireland. The results of these trials suggested the N-VIRO dredge to be more fuel efficient with less benthic impact and less damage to scallop. There was no reduction in catches associated with this dredge.
- The large-scale uptake of the pulse trawl has resulted in reduced ecosystem impacts on benthos and also a reduction in discards. A large-scale monitoring programme is currently being undertaken to fully assess these reductions.
- Several Dutch beam trawlers are testing a new T-Line concept using pins instead of chains to chase fish out of the seabed. The initial trials carried out in December 2011 were not particularly successful as the pins had a tendency to break off and catches of sole were low but a new version will be

tested later in 2012. The objective of this design is to reduce fuel and impact on the seabed.

- The development of a pelagic trawl fishery for cod and other gadoids in the Barents Sea will reduce benthic impact significantly. Pelagic trawling is permitted for trawlers that have applied for such a licence.

Several countries have looked at ways of reducing unaccounted mortality particularly in gillnet fisheries.

- Work has begun in Norway to reduce/avoid the effect of ghost fishing. Development of an intelligent buoy that transmits information (gear, position, owner, dates, etc.) to all traffic in the area and a computer program for forecasting deep-water currents (direction, intensity) in the traditional fishing grounds for gillnetting in Norway have recently commenced. The use of available underwater telemetric tracking technology is also being considered to track lost gears as well as the fishing properties of new biodegradable plastic materials in certain parts of the gear (use of PPS monofilaments).
- Trials on a 15m longliner have been continuing in Norway with a new automatic longline hauling system (ALH system). Observations have demonstrated lower losses of fish during hauling reducing unaccounted mortality in this fishery which can be significant. The ALH system also improved work and safety conditions on board the vessel.
- Two Norwegian coastal vessels (12 and 15 m) have been used to gather data from gillnet landings of prespawning cod. During these trials the effect on quality (graded by professional crew on the fish plant) as a function of soaking time and type of twines in the gillnets has been studied. It was clearly demonstrated that quality improved with reduced soaking time. In most cases fish were alive when the nets were retrieved after 8 or less hours. A similar effect was found when the nets were changed from mono- to multi-monofilament twines. Despite fish stayed longer alive in the multi-mono twine nets, soaking time still seems to be the most crucial parameter for the quality of gillnet-caught cod during winter.

Seals and other protected species continue to interact with fishing gear. Specific instances of fisheries interactions with protected species and associated mitigation measures reported:

- As reported in previous years from Ireland and the UK predation of fish catches by mainly Grey seals from gillnet/tanglenet fisheries continues to be a problem on all coasts of the UK and Ireland. Many inshore fishers have now stopped gillnetting as the level of damage is so high. A current Irish study is currently assessing the level of seal depredation in inshore fisheries around Ireland and has reported some seal bycatch along with depredation. This study is due to be completed in 2012.
- Observer programmes in the Irish pelagic trawl fisheries (mackerel, horse mackerel, blue whiting, herring and albacore tuna) implemented since 2005 have shown cetacean bycatch in these fisheries to be virtually non-existent. Only a single bycatch has been observed in the tuna fishery and none at all in the last 2 years.
- The UK has been testing an acoustic deterrent device (DDD-O3L) which has proved highly effective in reducing bycatch in the >12m gillnet fisher-

ies in ICES division VII (e, f, g, h and j). The UK authorities are planning to make the use of this device mandatory in these fisheries.

- A French consortium including the netmaker Le Drezen, the National Museum of Natural History, Ifremer and CNRS and the French Southern and Antarctic Lands (TAAF) launched the ORCASAV campaign which has begun experimental fishing trials for toothfish. These trials aim to test the effectiveness of the trap fishery, which could be an alternative or at least an extension to longlines, from which orcas and sperm whales have learned to predate, creating a serious economic and ecological problem. The results have demonstrated that these traps are feasible in this fishery.
- An Italian project is evaluating mitigation measures to reduce the bycatch of protected species in pelagic trawl fisheries in the Adriatic Sea targeting small pelagic species (Anchovy and Sardine). Following observer work the trials have concentrated on using a modified TED (*Turtle Excluder Device*) adapted to a single boat pelagic trawl. The preliminary results are encouraging. Next step will be to test the TED in a pair trawl which is the main activity in the Adriatic Sea.

Development of New Fisheries

Virtually no new fisheries were been reported in 2012. Experimentation of static gears as a means for targeting fish has continued although the indications are that these fisheries are still not economically viable in most cases. Examples of new fisheries are reported as follows:

- During 2010 and 2011, mainly in winter the squid have been abundant in coastal waters around northern Spain. Some artisanal vessels have carried out trials in this area during the night with jigging gear and artificial lights. If this fishery can be developed then it could lead to diversification away from traditional gillnet and longline fisheries in the area.
- Two Dutch vessels have converted to potting for crab due to high fuel prices and low returns from other fishing methods. No other details are reported
- The fishery for greater weever (*Trachinus draco*) in the Kattegat seen during 2010 and 2011 as continued. This fishery has developed as a consequence of low catches of *Nephrops* and cod during the first quarter of the year. The weever is also one of few species that are without limiting quotas and few regulations attached to it in the Kattegat.
- A recent study was carried out in cooperation with a coastal fisher in Malangen fjord (North of Norway) to develop a pot fishery for shrimp. The trials were carried out in June and in the same fishing area where the small coastal vessels regularly trawl. The catch rate of the pots was too low to draw any conclusions on the efficiency of the pots but the results of the study showed that bait conservation is one of the main challenges to establish such a fishery in Norway. Further studies covering different fishing seasons and areas are recommended in the near future.

10.4 Information for individual assessment working groups

Specific information relating to different areas and fisheries to be provided to Assessment Working Groups and other Expert Groups are detailed in Annex 5. Information is provided for the following WG's:

WGCSE	WGHMM
WGNSSK	AFWG
NWWG	WGWIDE
HAWG	WGNEW
WGANSA	WGECO
WGMME	WGSE
SGBYC	GFCM

Only limited information was supplied by the Baltic countries and is therefore not included.

10.5 Conclusions

WGFTFB concluded that it was worthwhile for the group to continue to collate this information on an annual basis subject to further revision of the questionnaire and better quantification of the information where possible.

Discussion

Repetition often in information, maybe change the ToR to another cycle, two-three years. In case of no changes, this could be indicated in a special box, in case of nothing was changed.

ToR A was started a few years ago by Dominic Rihan, Norman Graham and Dave Reid. The idea was to collect changes in fishing fleets and bring this information to the ICES community. The ICES stock assessment WG chairs do actually read the advice appreciate the effort and take it into account when they do their stock assessment.

It was recommended to provide the advice biannually and to consider stop calling it a ToR. There is a lot of repetition. The positive sign is that the information is used. A possible 2 year scheme will be checked with Dominic; this part of the meeting requires someone to embrace it fully. Discussion will continue intersessionally.

11 ToR B: Redfish Fishing Technology and Physiology (Bent Herrmann)

11.1 Background

Changes of mesh size alone are not believed to be an effective solution to the problem of redfish selectivity. Codends containing considerable amounts of redfish rapidly rise to the surface due to hydrostatic pressures and rather special conditions are thought to develop within the codend that can result in that the codend meshes opening up and which may lead to a considerable release of redfish during the haul back operation of the fishing gear. NAFO Scientific Council (SC) referred the issues of redfish selectivity and the loss of redfish by during the later stages of hauling when the net comes to the surface to the WGFTFB in 2010. NAFO SC proposed to investigate possible technical measures that could reduce the loss of redfish at the surface due to their developed buoyancy. WGFTFB considered this request initially at their 2010 meeting and worked by correspondence to draft a response for the NAFO SC meeting in September 2010. In responding WGFTFB have considered and reviewed available information on redfish selectivity and mitigation measures as well as experiments to assess the level of escapement and survival of escapees during the fishing process. A topic group was created in WGFTFB 2011 to address the issue of redfish selectivity. The present report reviews progress in the United States, historical data from German and Russian papers on stickers, older data from Norwegian grid studies, and newer data from Iceland.

11.2 General Overview

Bent Herrmann introduced this ToR at plenary. The participants met for two days. Several individual presentations were held. Also, discussions were held in response to new information. In particular, the details of redfish selectivity were discussed: what factors influence stickers? When do redfish escape? Can stickers and high levels of visible surface mortality both be avoided? It was agreed within the group that the ToRs established had largely been met, and that the network established by the group's activities could continue independently of WGFTFB. Past and future collaborations were discussed. More than one scientific paper can be attributed to the group's activities.

11.3 Terms of Reference

Redfish are primarily harvested by trawls – either pelagic or bottom trawls. Due to their relative small sizes and their distribution in vertical columns, they offer both an opportunity and a challenge to sustainable harvesting. In light of a NAFO request for more information on redfish harvesting, trawl codend selectivity, as well as challenges in under-harvesting of redfish resources in Northeast US., WGFTFB topic group of experts met in Lorient in 2012 to continue the following terms of reference:

- i) Create an inventory of gear specifications (such as mesh size, trawl design, trawl orientation) used in harvesting redfish in member countries;
- ii) Describe and synthesize research carried on size selectivity with various mesh sizes and configurations and investigate possible technical measures that could reduce the loss of redfish at the surface due to their developed buoyancy;
- iii) Collect morphometric information necessary to predict size selectivity;

- iv) Examine habitat use, especially water depth and water columns, by major commercial redfish species and application of the information for selective capture by trawls.

11.4 List of Participants

NAME	INSTITUTION	E-MAIL
Bent Herrmann	DTU Aqua, Denmark	bhe@aqua.dtu.dk
Mike Pol	Mass. Division of Marine Fisheries, US	mike.pol@state.ma.us
Alexander Pavlenko	Knipovich Polar Research Institute of Marine Fisheries and Oceanography(PINRO), Russian Federation	pavlenkorybak@gmail.com
Manu Sistiaga	SINTEF Fisheries and Aquaculture, Norway	manu.sistiaga@sintef.no
Bjørnar Isaksen	Institute of Marine Research, Norway	bjornar.isaksen@imr.no
Olafur A. Ingolfsson	Marine Research Institute, Iceland	olafur@hafro.is
Pingguo He	School for Marine Science and Technology, US	phe@umassd.edu

11.5 Individual presentations

11.5.1 A Network to Redevelop a Sustainable Redfish (*Sebastes fasciatus*)

Trawl Fishery in the Gulf of Maine (Mike Pol, Mass. Division of Marine Fisheries, USA)

A progress report was made on this project, which is underway. The initial phase of the project completed 85 hauls on 45 commercial vessels to explore the spatial and temporal distribution of the fishery, and to determine any bycatch problems. In this phase, commercial practice was followed to a broad extent. A smaller mesh (114 mm) than standard was used. Exploratory fishing (85 hauls/5 vessels) strongly suggests bycatch of undersized redfish and groundfish species is minimal. Further marketing and processing steps are under development. Codend selectivity testing will continue in 2012 under the direction of Pingguo He. Bycatch reduction phase's goal may be improved selectivity through the use of a multi-grid system. Outreach and implementation is on hold for now. Network approach appears to be working by flexibly responding to changing needs and by sharing information and planning among broad expertise.

Discussion

Herrmann *et al.*'s recent paper predicts a 40 cm L50 for 165 mm mesh, one of the sizes to be tested. Length frequencies from Exploratory Fishing show no or nearly no redfish at that size were caught. Commercial fishers use 165 mm to target redfish; therefore they must be defeating the selectivity of the codends to catch fish. Opportunities for collaboration between the participants in the redfish group were explored. Further advice on use of square mesh was discussed.

11.5.2 Grid selectivity for redfish (Bent Herrmann, DTU-Aqua)

As a result of the meeting of the topic group in 2011, additional data from Roger Larsen of the University of Tromsø from 2009 and earlier was made available on the use of the Sort-X system, with different grid spacings (40, 45, 50 mm). The selectivity curves suggest that not all redfish are coming into contact with selectivity devices

(the grid and codend). The results of this analysis are currently in manuscript form in preparation for submittal to a journal. A table of L50 by grid size will be included in the manuscript.

Discussion

The relative escape mortality of grids vs. codends was discussed. It was mentioned that one of the participants had co-authored a paper on this topic for haddock and found no difference in mortality between grid escapees and codend escapees. It was generally discussed that haddock are likely more sensitive than *Sebastes* species. It was noted that Faroese experiments with saithe may have been conducted by Bjarti Thomsen; also Bill Hickey may have collected some video footage of redfish in contact with a grid. Mike Pol offered to investigate his video library for these tapes.

11.5.3 Sticking of redfish in trawlnetting (Discussion)

Mike Pol reported that fishers were not interested in testing square mesh codends for selectivity because they would never use square mesh for concern over sticking; this concern persists despite no directed fishery for years. Isaksen confirmed his experimental experience that redfish can be very difficult to remove from the net due to their physiology. In square mesh, it may be necessary to cut every fish that is stuck in half. Herrmann and Sistiaga proposed to conduct an experiment to test the difference in sticking between square and diamond mesh of the same size.

It was theorized that the redfish wriggle through meshes, using their scales to gain purchase on the twine.

An appropriate experimental design was discussed. A three-compartment analysis would be necessary – the stuck fish would need to be characterized for length along with the experimental codend and the non-selective codend in a selectivity experiment.

11.5.4 Some aspects of Redfish Selectivity (A. Pavlenko, PINRO, Russian Federation)

Morphological measurements and data on stickers were uncovered from eight papers in the German and Russian literature, interpreted by Pavlenko. Investigations included comparisons of the maximum circumference of *S. mentella* in the Barents Sea vs. its length, separated by male and female by Shestov (1962). No differences were found. On the Newfoundland Bank, some differences between sexes were observed. Yanulov (1960) and Kotthaus (1950) found conflicting results when comparing maximum circumferences of *S. marinus* and *S. mentella*. Yanulov found no difference; Kotthaus found more than 1.8% difference per length class.

Treshev (1966) reported on sticking rates in a polyamide redfish net. Thirteen percent of the total catch was stuck in 129 mm mesh in the front part of the net; 10% of the total catch was caught in a codend of 118 mm. In a manila trawl, 9.6% of the total catch was meshed in the front part of a 129 mm net; in the 92 mm codend, 3% were meshed.

Figure 3 from Treshev (1966) of the relationship between the percent stickers and the ratio of the fish circumference and the mesh circumference was reproduced.



Figure 3. Relationship between redfish stickers and ratio of circumferences of redfish and mesh (Treshev, 1966).

The results indicate that when the ratio of circumferences are above or close to unity, or where the fish is slightly larger, as much as 30% per length class may be stickers. The maximum sticking rate per length class occurs between a ratio of 1.02 and 1.11.

Literature Review of Redfish selectivity aspects:

Shestov, V.P. Works of VNIRO/ Vol. XLVI. 1962. (in Russian).

Tolmachev, V. I. Determine of maximum length of fish which are completely retained by strain off gears. Kaliningrad, 1963. (in Russian).

Treshev, A. I. Works of VNIRO/ Vol. LXI. 1966. (in Russian).

Treshev, A. I., Shestov V. P., et al. ICES. 1967. (in Russian).

Brandt, A. V. Selection of Redfish. International Council for the Exploration of the Sea. Comparative fishing Committee, No. 10. C.M., 1960.

Templeman, W. Selection of redfish. Joint Sc. Meeting, S-21, Lisbon, 1957.

Yanulov, K. P. At question of location of Redfish schools of Newfoundland and Labrador regions. A collected works "Soviet fishery research in Seas of European North". Press magazine "Rybnoe hoziaistvo", 1960. (in Russian).

Kotthaus, A. Rassenuntersuchungen am Rotbarsch. Berichtr deer Deutschen Wissenschaftlichen Kommission fur meersforschung XII, 94–114, 1950. (in German).

Some modern data from the NAFO area was presented that suggests that the NAFO mandated mesh sizes of 130 mm allows for noticeable escapes at the surface. Similar to data presented by Pol, the L99 for 130 mm was compared to length distribution of beaked redfish abundance from EU bottom trawl survey, and was found to be 20 cm greater than the mode of the survey distribution. A photo of surface escapees and a video were shown.

Discussion

It was theorized during discussions that redfish may not be escaping during towing, and that the escapes only occur at the surface because of buoyancy or because of reduced tension on the codend twine. An experiment using the Norwegian multi-sampler was recommended to establish when escape occurs; this information powerfully affects decisions on mesh sizes in redfish fisheries, as observed mortalities pro-

vide better information on removals from the fishery than unobserved mortalities. Video of redfish codends would also be useful in this regard.

11.5.5 New Data from Iceland (O. Ingolfsson, Marine Resources Institute)

Data from Iceland fits well with existing data and predictions. There is evidence that not all redfish attempt to escape or do not have the opportunity to escape through codend meshes.

11.6 Recommendations and findings

- 1) Terms of reference have been achieved to an acceptable level.
- 2) Collaborations have been established between members and will continue outside the context of meetings of WGFTFB. One published paper (Herrmann, B. *et al.*, 2012. Understanding the Size Selectivity of Redfish (*Sebastes* spp.) in North Atlantic Trawl Codends. Journal of Northwest Atlantic Fishery Science, 44, pp.1–13) and others in development arose from the topic group.
- 3) The group should dissolve.

Discussion

Haul-back selectivity is an important issue often neglected. This might also give additional stress, and may result in unaccounted mortality. Does it only occur at the surface, or at a certain depth?

12 ToR C: Use of Artificial Light in Fishing (Heui-Chun An, Mike Breen, Odd-Børre Humborstad, Yoshiki Matsushita)

12.1 Terms of Reference

A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions.

Specifically the group aims to:

- 1) Describe and summarize fish response to artificial light stimuli;
- 2) Describe and summarize use of artificial light in world fisheries;
- 3) Describe and tabulate different light sources to attract fish;
- 4) Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions; and
- 5) Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods.

12.2 Introduction

This was the first meeting of the Topic Group on the Use of Artificial Light in Fisheries. The ICES/FAO WGFTFB presented an idea forum in which to coordinate the research activities of scientists from the ICES community, with an interest in developing light as an innovative technique, with scientists from the FAO community (particularly Asia), who have a great deal of experience working with traditional light fisheries. The main aim of the meeting was to identify what experience and knowledge was available to the group and then devise a rational plan for addressing the Terms of Reference (ToR).

From the onset, it was recognized that the work of the Topic Group would require a multidisciplinary approach, if the ToR are to be addressed properly:

- physics and measurement of artificial light in water;
- engineering and design of artificial lights, including the development of energy efficient light sources;
- biology of vision, in particular recognition of the natural limits and variation;
- behavioural responses of fish to artificial light; and
- technological application of artificial light in fisheries, including novel and innovative approaches.

The overall objectives of this meeting, therefore, were to summarize the group's current knowledge and experience with artificial light in fishing (sessions 1, 2 and 3) and then identify what actions are required to answer the questions raised by the terms of reference (session 4).

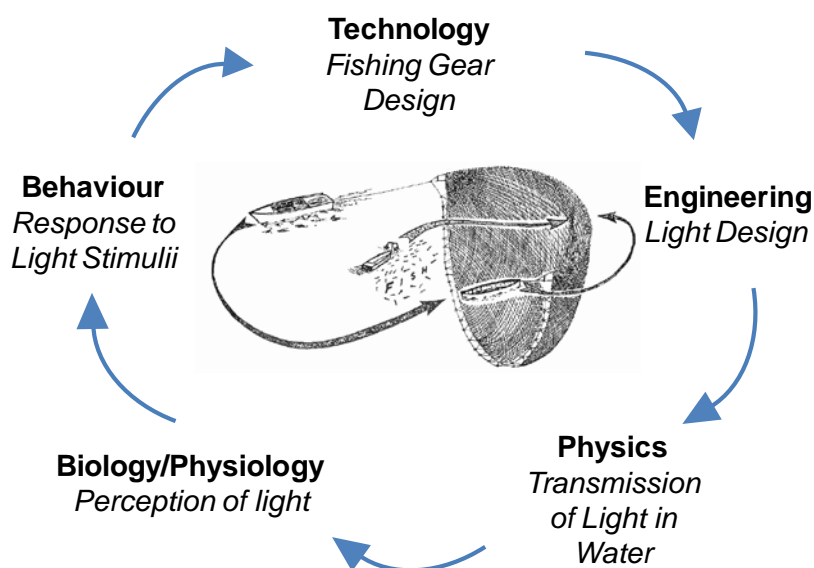


Figure 4. Artificial Light in Fishing – a multidisciplinary challenge (Illustration from Ben Yami, 1978).

12.3 List of Participants

Name	Institution	Email address
Heui-Chun An §	NFRDI	anhc1@nfrdi.go.kr
Simon Armstrong	CEFAS	simon.armstrong@cefass.co.uk
Luis Arregi	AZTI-Tecnalia	larregi@azti.es
Bjørn Erik Axelsen	Institute of Marine Research	bjorna@imr.no
Gérard Bavouzet	IFREMER	gerard.bavouzet@ifremer.fr
Mike Breen §	Institute of Marine Research	michael.breen@imr.no
Christopher Glass	University of New Hampshire	chris.glass@unh.edu
Pingguo He §	University of Massachusetts Dartmouth	phe@umassd.edu
Einar Hreinsson	Marine Research Institute	eihreins@hafro.is
Odd-Børre Humborstad § @	Institute of Marine Research	oddb@imr.no
Hjalti Karlsson	Marine Research Institute	hjalti@hafro.is
Sven Gunnar Lunneryd	Swedish University of Agricultural Sciences	sven-gunnar.lunneryd@slu.se
Svein Løkkeborg	Institute of Marine Research	svein.lokkeborg@imr.no
Yoshiki Matsushita §	Nagasaki University	yoshiki@nagasaki-u.ac.jp
Sonia Mehault	IFREMER	Sonia.Mehault@ifremer.fr
Bernd Mieske	Institute of Baltic Sea Fisheries	bernd.mieske@vi.bund.de
Anne Christine Utne Palm	Institute of Marine Research	annecu@imr.no
Petri Suuronen	FAO	petri.suuronen@fao.org
Maria Tenningen	Institute of Marine Research	maria.tenningen@imr.no
Benoit Vincent	IFREMER	benoit.vincent@ifremer.fr

§ Convener

@ By correspondence

12.4 Background

It is thought that artificial light, in the form of fire, has been used in fishing for thousands of years (Ben Yami, 1978). In the presence of artificial light, pelagic fish often school and move towards the light source and this technique is successfully employed in several fishing methods (Ben-Yami 1978; Gabriel *et al.*, 2005). Commercial applications of light in purse-seines, lift nets, and squid jigging are widely practiced, especially in Asian-Pacific countries. In jigging, hook and line, dipnet and purse-seine fisheries, artificial light sources are used to attract and aggregate squid and pelagic fish such as sprat, herring and mackerel (Ben-Yami, 1988). In long-lining, light-sticks are widely used to encourage swordfish to ingest the baited hook (Hazin *et al.*, 2005).

Indeed there are few fishing practices in which light is not sometimes used to attract or concentrate fish, and few fishing gears that are not sometimes used in combination with light to attract the fish (Gabriel *et al.*, 2005).

Today, fire and gas lamps have been replaced by incandescent lamps, metal halide lamps or fluorescent lamps as the source of light these fisheries. While more convenient, safer and significantly more powerful, with respect to the light emitted, these lamps have generated new problems for the light fisheries in which they are used. First, competition between boats and métiers has led to an excessive level of light output from many established fisheries (Matsushita *et al.*, 2012). As a result, the vessels incur increasing fuel costs and have an increasing environmental impact, in terms of light pollution and CO₂ emissions. Furthermore, this excessive level of competition, if unchecked, could easily generate a technological creep in catch per unit of effort and thus lead to overfishing.

Commercial applications of artificial light for fishing have tended to be confined to surface or subsurface lights in fisheries that target pelagic and schooling species. Technological limitation partly explains the lack of application in demersal and deep water fisheries. Light systems operated at greater depths have mainly used battery packages for energy supply because cables were impractical. These batteries were heavy with a comparatively short life time and therefore not suitable. However, recent technological advances in battery and modern LED light technologies (Inada and Arimoto, 2007) have made available small, robust, powerful and energy-efficient light units that can be used in deeper waters for both static (e.g. pots and longlines) and towed fishing gears (e.g. trawls). Moreover, these new energy efficient light sources are continuing to develop and may be used to develop energy efficient and environmentally friendly fishing technologies for existing light fisheries.

Many explanations have been offered to explain why fish respond to light, including conditioned responses to light gradients, curiosity, social behaviour, phototaxis, optimum light intensity for feeding, and disorientation and immobilization due to high light levels (Arimoto *et al.*, 2011). However, despite many years of research into fish visual systems, knowledge of the role of vision in the capture process is still limited. The functional explanations for responses to light, whether repulsion or attraction, include predator avoidance and enhancement of feeding efficiency (Pitcher and Parrish, 1993). The type of responses and their functional explanations depend on species, ontogenetic development, ecological factors, and physical characteristics of the light source (intensity and wavelength; Marchesan *et al.*, 2005). As technological improvements enable research into the responses of species previously unexposed to artificial light (i.e. in demersal and deep water fisheries), there is great potential for developing innovative solutions to longstanding bycatch and selectivity challenges using artificial light.

A synthesis of the knowledge of light fishing and the fundamental responses of fish to artificial light will provide a comprehensive overview of the topic and stimulate research into the innovative application of artificial light; in both established light fisheries and in demersal and deep water fisheries, where the technology remains relatively untested. There is considerable potential for artificial light to be used constructively in the development of more efficient and responsible fishing methods. This ICES/FAO Topic Group on the Use of Artificial Light in Fisheries offers an important opportunity to combine and coordinate the research activities of scientists from the ICES community, with an interest in developing light as innovative tech-

nique, with scientists from the FAO community (particularly Asia), who have a great deal of experience working with traditional light fisheries.

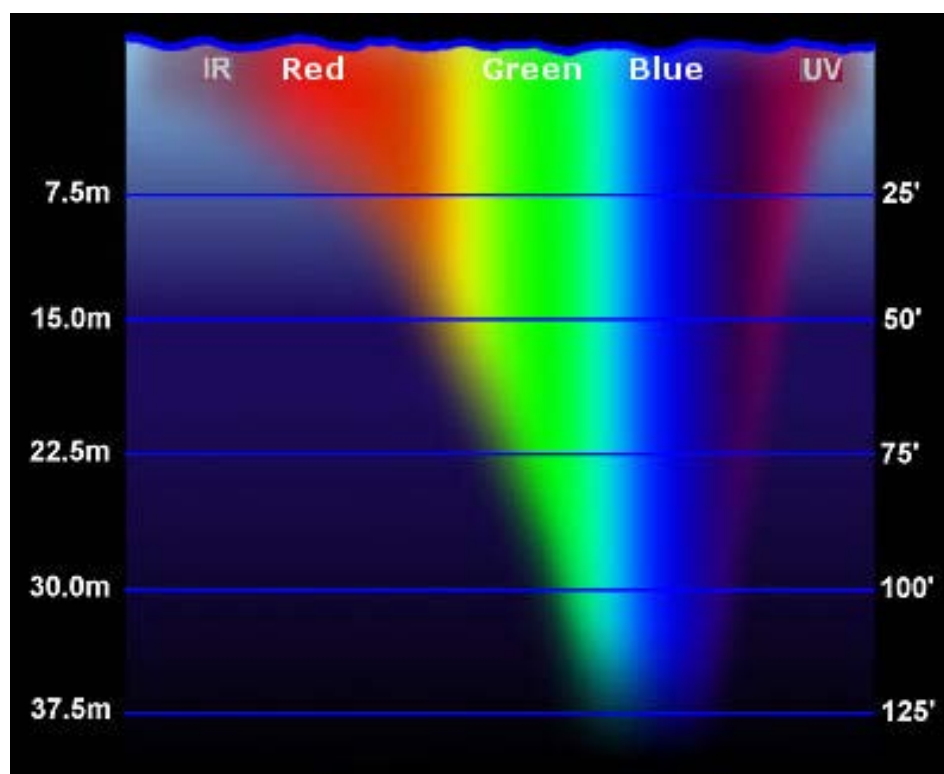


Figure 5. The spectral transmission of light in the open oceans: demonstrating the attenuation of different wavelengths of light, with greatest penetration in the middle wavelengths (450–570nm; blue and green) in comparison to longer (>620nm; red) and shorter (<450nm; violet and ultraviolet) wavelengths.

(Reprinted from <http://ultramaxincorp.com/?p2=/modules/ultramax/catalog.jsp&id=23>; cited by Arimoto *et al.*, 2011).

12.5 Session 1 – An introduction to the properties of light underwater and the biology of underwater vision

12.5.1 Light and Vision: Use of Artificial Light in Fishing Operations (Christopher W. Glass).

To fully understand the process by which artificial light can be used to attract or repel fish from light sources for the purposes of fishing, there is a need to understand the structure and function of the fish eye and the natural underwater light environment against which fish must form visual images. This presentation provided an overview of both the fish eye (its form and function) and the underwater view; for further information see the review of “Fish vision and its role in fish capture” by Arimoto *et al.*, 2011. The units of measurement of both radiant and reflected light were discussed. A generalized model of the fish eye was presented and details of image formation, visual acuity and spectral sensitivity were outlined. The implications of these to image formation underwater were reviewed. Finally, issues relating to the use of light as attractant or repellent stimuli were discussed.

12.5.2 Colour vision in fish – pigment adaptability and lens flexibility (Anne Christine Utne Palm).

Visual detection of prey colour or contrast, is dependent on environmental light intensity and wavelength conditions, colour of prey in given environmental light conditions, the lens light and wavelength transmission and the visual pigments present in the retina.

The ToRs were mentioned. Artificial lights, light stimuli, use of lights, light sources, all these are challenges. A multidisciplinary approach is needed. Light use is old. Aspects are: technology, engineering, new developments (LED), physics of light transmission depending of wavelength, biology and physiology of light perception, behaviour and response to light stimuli. The question was raised whether there is a need to attract new disciplines. Gaps in knowledge should be identified, and sources of information.

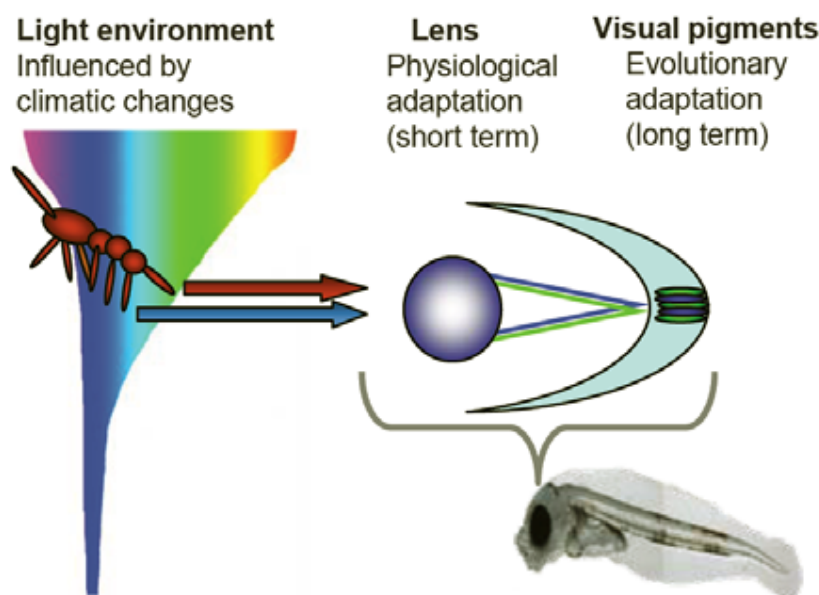


Figure 6. Visual detection in fish, which is influenced by the ambient light environment, short term physiological adaptations (e.g. in the structure of the lens) and long-term evolutionary adaptations (e.g. in the composition of visual pigments in the retina). Figure by Jon V. Helvig, Dept. of Biol., Univ. of Bergen.

Sunlight's wavelength composition changes as it travels through the water, due to the absorption of the water itself and due to scattering and absorption by particles within the water (Figure 5). The longer wavelengths are first absorbed by the water, thus the blue (or the shortest wavelengths) tend to dominate the deeper part of the ocean, while shallow coastal water is greener and even yellow to red, the more freshwater and humus it contains.

A fish will have much sharper vision (better contrast), if it is most sensitive to that part of the spectra where the water is absorbing the least. Thus, most fish species have visual pigments matching the dominant wavelength composition of their natural environment. Accordingly, an experimental study on the two-spotted goby (*Gobiusculus flavescens*) showed that the goby more than doubled its prey detection distance if given wavelength conditions matching its cones' peak sensitivity, com-

pared to when wavelength conditions were offset from its peak sensitivity (Utne-Palm and Bowmaker, 2006).

Further, studies of intra specific variation in cone sensitivity have shown that species can adapt to spectral composition of their local environment. For example, a sand goby (*Pomatoschistus minutus*) living in the oligotrophic clear water of the Mediterranean has cones shifted more to the blue-green than the sand goby living around the British Isles, while sand gobies in the turbid and brackish influenced Baltic ocean possess cones shifted much more to the red than any of its fellow European sand gobies (Jokla *et al.*, 2003).

The human eye focuses by changing the lens shape, while the fish eye lens has a constant shape (mostly round) and is focused by moving the lens backwards closer to retina or forwards towards cornea. It has recently been discovered that marine fish possesses multifocal lenses, which can compensate for the chromatic defocusing of different wavelength (Kröger *et al.*, 1999). Additional studies have shown that the multifocal lens is very flexible – adapting to the available wavelengths to which the eye is exposed. The optical properties of the lens can change within hours. For example, it adapts to day and night vision (triggered by dopamine; Schartau *et al.*, 2010).

The visual pigments of a fish species are genetically determined. The amounts of expressed pigment, however, have been shown to change in response to environmental light conditions. For example, fish exposed to long-term deprivation of short wavelengths showed an increase in the proportion of long wavelength sensitivity cones and a decrease in short wavelength sensitivity cones (Wagner and Kröger 2005; Kröger *et al.*, 2003).

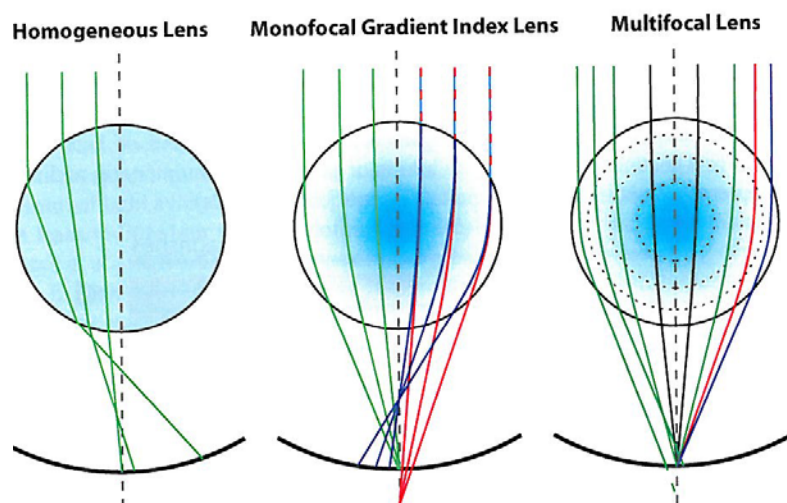


Figure 7. Chromatic focusing in different eye lenses, demonstrating how a multifocal lens can compensate for the chromatic defocusing of different wavelengths observed in homogeneous and monofocal lenses (Gustafsson, 2010).

Discussion

It was recognized by the group that there are many units used to describe light in the scientific literature. It was unclear which units are best suited for the study of the vision and behaviour of fish, and other marine fauna, particularly with respect to their responses to artificial light. It was highlighted that it would be important to measure, or at least provide reliable estimates of, the total available light (electromagnetic radiation) over a sufficiently wide range of wavelengths (i.e. using radio-

metric methods), as opposed to using photometric units and methods which have been calibrated to the spectral sensitivity of the human eye. This would then allow the observations to be related to the spectral sensitivity of a particular species. It was felt that the group should review the available protocols and technologies for measuring light, and provides some guidance on standardization of protocols for studying fish behaviour. It was noted that phytoplankton research and the approach this field has taken to the standardization of light measurement would provide a useful source of information.

The group identified a clear need to describe the range of visual sensitivity in commercially important marine and aquatic species. There is a growing body of scientific literature now available on the occurrence different retinal pigments in various marine and aquatic species. It was felt that a review of this literature would provide a useful overview of the visual spectrum of many commercially important species, with respect to their natural behaviour and ecology.

12.6 Session 2 – National/Regional overviews of the use of artificial light in fisheries, and any associated research.

12.6.1 An overview of the use of artificial light in world fisheries (Mike Breen)

In an attempt to present an overview of the use of artificial light in world fisheries (ToRs 2 and 3) contributors to the topic group were asked to complete Annex 6: A Partial Global Summary of the Fisheries Using Artificial Light providing details of fisheries using artificial light in terms of the target species, area of operation, fishing gear and the type, placement and power of the lights used. This overview was compared with the only other known overview of artificial light fisheries, Ben Yami (1976), by simply comparing the number of species exploited using artificial light in each region (Figure 8 and Figure 9). There were clear differences between these two overviews, however this was thought to be primarily due the topic group's current limited knowledge of light fisheries in some areas, in particular the Mediterranean Sea, Atlantic Ocean and inland waters.

However, the records of light fishing in two of the regions (W. Pacific and S.E. Asia) are thought to be the most accurate and complete in the dataset. Interestingly, both of these regions show a substantial increase in the number of species caught using light, in comparison to Ben Yami (1976). Whether this increase is representative of other regions is uncertain, however it should be noted that light fishing is thought most prevalent in the Asian fisheries.

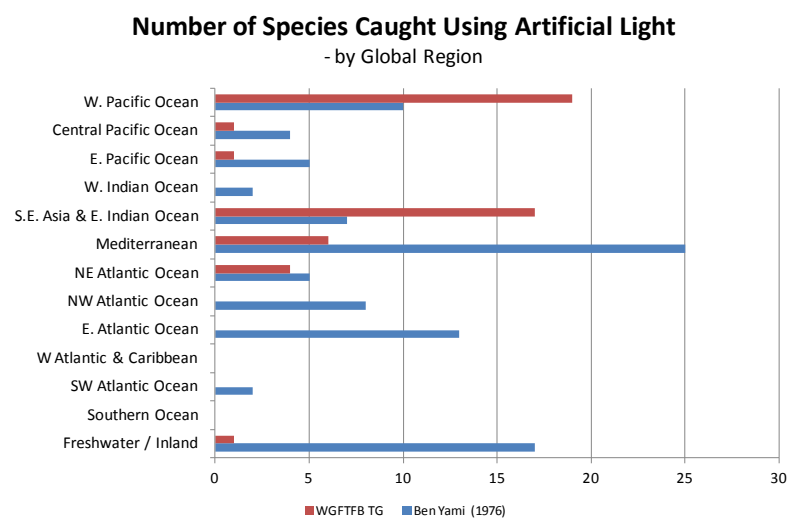


Figure 8. An overview of the number of species caught using artificial light, by global region. For more details see Annex 6: A Partial Global Summary of the Fisheries Using Artificial Light and Ben Yami (1976).

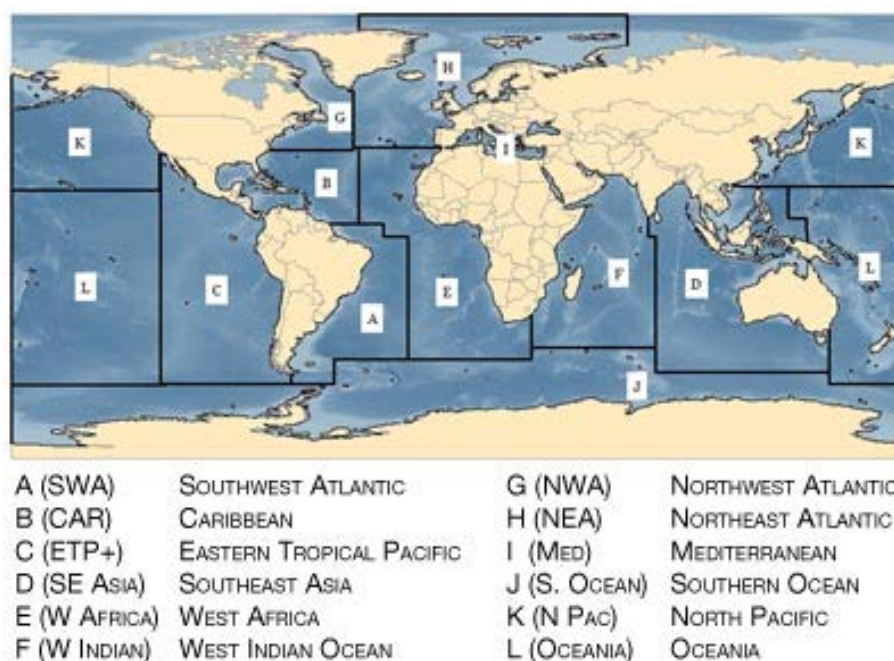


Figure 9. A definition of global regions referred to in Figure 8.

12.6.2 Artificial light in fishing in France (S. Méhault and F. Morandeau)

In France, artificial light is used in the Mediterranean Sea, mainly in the Languedoc Roussillon region. The technique, called “lamparo”, is originally from Spain. The main target species is sardine (90% of recorded catch), but anchovy is also taken. The fish are first attracted by a small boat equipped with a lamp (typically ~38A) to attract them. Once enough fish have gathered under the light, a larger boat catches the fish using a purse-seine. Nowadays, less than 10 artisanal boats are using this technique but they are facing difficulties due to the scarcity of the resource.

This presentation also included a brief review of experimental work investigating the use of artificial light as an attractant in fish pots.

12.6.3 Attraction and trapping of cod using artificial light (Einar Hreinsson)

During experiments where cameras with artificial lights were used to observe fish behaviour, considerable concentrations of krill (euphausiids) were observed around the camera lights at night. Cod seemed to be attracted to the krill and fed on it during the dark hours. The presentation described pilot fishing trials with a cylindrical trap (3m (diam) x 1.4 m (height) fitted with small LED light for krill/cod attraction resulting in catch rates of 9–10 kg/day/m³ of trap volume. Based on this catch rate, it was estimated that the catch from 10 pots fitted with lights would be comparable to a typical longline operated in the area.



Figure 10. Cod and haddock feeding on krill (*Thysanoessa sp.*) attracted to LED light.

12.6.4 The use of artificial light in fisheries (and associated researches) in Japan and the Pacific region (Yoshiki Matsushita)

Japan's capture fisheries production was 4.15 million tons in 2009. The most productive fishing methods, in terms of catch weight, are: purse-seines, towed nets, set-nets (fish trap), stick-held dipnets, gillnets, longlines and squid jigging. Among those fishing methods, more than half of the purse-seine vessels and all stick-held dipnet and squid jigging boats use artificial light. Thus, light fishing is quite common in Japan. In purse-seine fisheries (that mainly target chub mackerels, horse mackerels and sardines) surface and underwater lamps are used, while only surface lamps are used for stick-held dipnet targeting Pacific saury and squid jigging fisheries. Since fishers generally believe more light leads to greater catches, to avoid light competitions within sectors and conflicts between sectors the maximum power output for lighting is controlled by regulations, according to: fishing methods, regions, boat sizes, etc.

Engineering design of the light source should include arrangement of light source(s), light intensity, wavelengths, light distribution and its life cycle. Physical characteristics of seawater such as the diffuse attenuation coefficient and its variation with depth and season should be taken into account for better application of the light source. The behavioural/physiological principles of fish attraction to the light should be investigated, but its mechanism has not yet been well-explained, scientifically. For example, the squid jigging boat usually set lamps over the deck to create shadow/dark zone under the boat where squids are hooked. In contrast, lamps are set at the outer side of the boat in purse-seine and stick-held dipnet fishing and fish are directly exposed to the light (Figure. 8).



Figure 11. Squid jigging (left; only surface light) and purse-seine boats (right; surface and underwater lights).

These differences in lamp arrangements are considered to reflect fish behaviour and potential reasons of fish attraction are considered as following (Arimoto *et al.*, 2011).

- Schooling for feeding
- Conditioned response to light intensity gradients
- Curiosity behaviour and other social behaviour
- Positive phototaxis making them orient to the light source
- Optimum light intensity for feeding and other activities
- Disorientation and immobilization due to high light levels in surrounding dark conditions

Fish attraction to light may be the consequence of a combination of these reasons.

Nagasaki University has been conducting research in relation to light fishing including: coastal purse-seine, squid jigging and handline fishing. In coastal purse-seine in Nagasaki, retina samples of anchovy were collected during the night, under natural conditions and after exposure to fishing lights, to investigate the effect of artificial lights. Retinas exposed to fishing light were well light-adapted compared to those sampled under natural (dark) conditions (Figure 12). However, there was also evidence of a circadian rhythm. Light adaptation was high after sunset and before sunrise, i.e. when the largest catch is expected (Figure 13). It is suggested that the light adaptation of the retina enables recognition of other individuals, thus allowing the aggregation of schools.

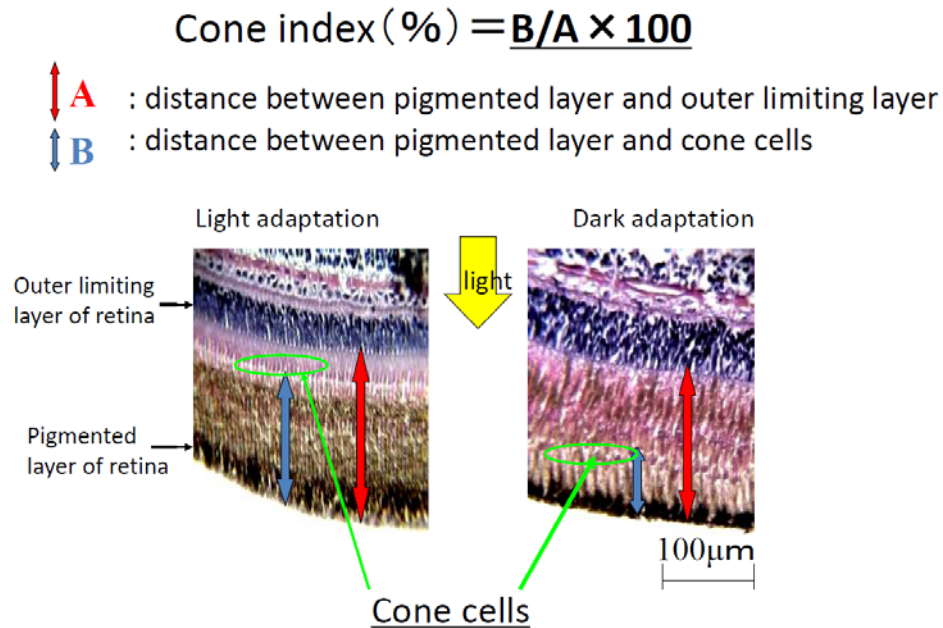


Figure 12. Light adaption in the retina of the anchovy (*Engraulis japonica*) caught in purse-seines; showing the calculation of the “cone index”.

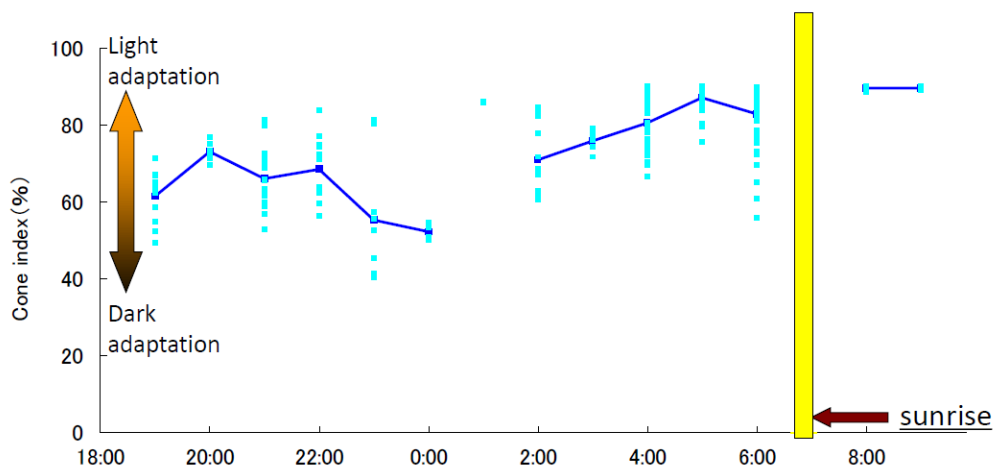


Figure 13. Temporal variation in the cone index of the retinas of the anchovy (*Engraulis japonica*).

12.6.5 Use of artificial light in Asian fisheries (Heui Chun An)

This presentation introduced and gave detailed descriptions, with animations, of the many fishing techniques using artificial light in Asian countries including Korea, Malaysia, Vietnam and Philippines. The use of artificial light in fishing is an old technique; the Israelites used torchlight for the castnet fishery in Galilee in the 7th century. The squid jigging, hairtail angling, anchovy scoop net, purse-seine, stick-held dipnet are the typical light fisheries in Korea. Squid jigging fishery is the most common method, with around 3,000 fishing vessels engaged. The vessels use electrical fishing lamp from 81kW to 141 kW in power, depending on the size of the vessel. Hairtail angling is the second most common method, with around 1,000 fishing vessels engaged. The vessels use electrical fishing lamps of around 60 kW. A review of fishing gear and methods of Malaysia in 1995 stated that high-pressure gas lamps and fluorescent lights were used as attractors in purse-seine fisheries. In addition, it also described a method of attracting a fishing school with the lamp installed at the head of

vessel and catching the fish with a castnet. A review of fishing in Vietnam in 2002 explains that luring lift net, hook and line for flying squid, stick-held dipnet for anchovy and stick-held falling net for squid were also used in Vietnam. Another review in 2003 illustrates purse-seine and scoop net were used in association with light in the Philippines.

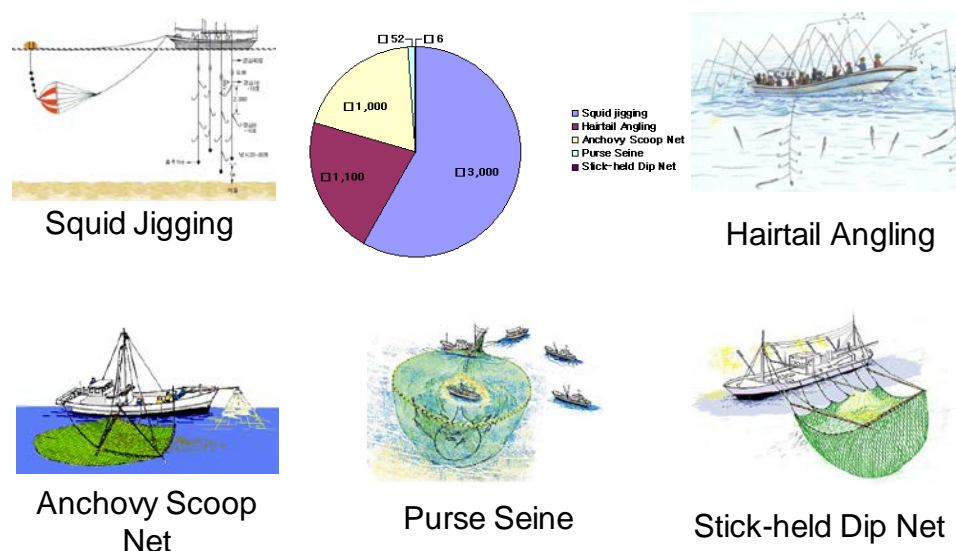


Figure 14. Examples of fishing techniques using artificial light in Asia.

12.6.6 Energy saving effect of LED fishing lamps for angling and jigging boats (Heui Chun An, Bong Seong Bae, Kyoung Hoon Lee, Seong Jae Jeong, Jae Hyun Bae and Seong Wook Park)

This presentation summarized research aimed to develop a highly efficient LED fishing lamp for the hairtail angling and squid jigging fishery to reduce fuel consumption and greenhouse gas emissions. Korean commercial fishing boats use a conventional metal halide lamp, which consumes fuel accounting for 65% of the total fuel consumption of the fishing boats. In this study, combination of LED lamp and metal halide lamp was used to investigate catch efficiency and fuel consumption. A 180W LED lamp unit with air-cooled system was installed on a 9.77-ton angling boat. Catch efficiency and fuel consumption of vessels equipped with LED lamp and metal halide lamp were compared with those with metal halide lamps during fishing season of 2009 to 2011. Catch efficiency of vessels with the LED lamps was equal to or marginally higher than those with metal halide lamps. As for fuel consumption, LED lamps were shown to save 55% of energy use of metal halide lamp in hairtail angling and 26% in squid jigging.

Table 1. The power usage and relative catches of squid jigging boats using LED and/or metal halide lamps.

Vessel	Lamp	Power (kW)	Fishing day	Catch (kg)	Mean Catch (kg/day)
LED1	L 180W 140 +M 1.5kW 16-28	49 – 67 (Mean 58.2)	14	8,964	640.3
Metal1	M 1.5kW 54	81	9	3,594	399.3
Metal2	M54	81	8	8,352	1,044.0
Metal3	M54	81	10	4,826	482.6

12.6.7 Grazing cod on euphausiids in pen – reduced feeding? (Hjalti Karlsson)

Based on the results of another project “attraction and trapping of cod” this small pilot study was carried out. The objective was to investigate whether it would be possible to attract, with lights, enough krill (euphausiids) into cod pens to reduce the need for feeding. Two fish-farming pens were positioned in Isafjord in NW Iceland on 55 m depth, 0.5 nm apart from each other. Two groups (400 fish) of cod were collected, measured and tagged, one as a control. In the control pen there was no feeding and no light, but in the experimental cage, three LED lights and no feeding. The experimental cage was monitored using a video camera via an Internet link. The experiment was carried out from 20/1 – 20/4 2011. Over this period the growth rate ($G = 100 (\ln Wt_2 - \ln Wt_1)/dt$) in the control pen was -0.04 and in the experiment cage 0.08. Due to the increased interest in krill (*Thysanoessa inermis* and *T. raschi*) in Isafjord, the presentation also described preliminary research into the assessment of the krill populations.

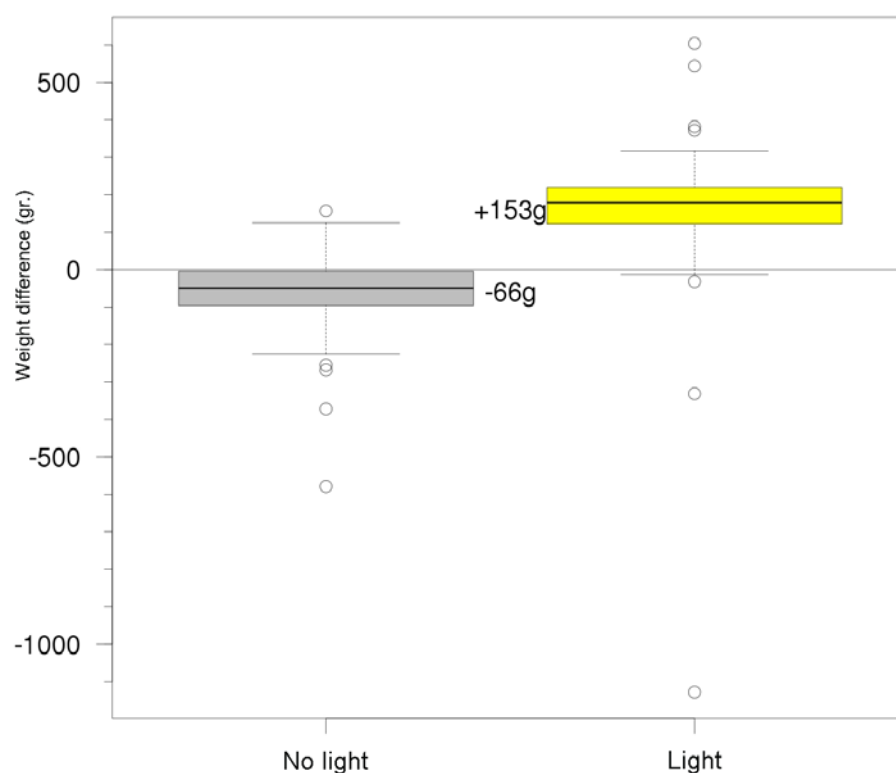


Figure 15. The change in weight of cod held in cages with and without lights (and associated krill attraction) for four months (January-April).

12.6.8 Use of artificial light in Norwegian fisheries (Svein Løkkeborg)

In Norway, artificial light is used only in the purse-seine fisheries along the coast of western and southern Norway (i.e. the North Sea and Skagerrak). Using light is banned north of the 62°N latitude. The purse-seine fisheries using light target sprat (*Sprattus sprattus*), Norwegian spring-spawning herring (*Clupea harengus*), mackerel (*Scomber scombrus*) and saithe (*Pollachius virens*). According to estimates of an experienced fisher, 70–100% of the catches in these coastal fisheries are taken using light.

The lights used are sodium vapour lamps (12–15 kW). The lamps, normally 10–15 lamps, are placed on board an anchored vessel. The target species is attracted to the light and, when adequate quantity of fish is aggregated under the lightvessel, the purse-seiner sets the gear around the school. These relatively small vessels are using light to aggregate fish because their gears are not large enough to catch large quantities of fish dispersed in deep waters.

The presentation also discussed preliminary trials investigating the use of light in fish pots, as well as trials directed at catching fish aggregations (primarily saithe) gathered around aquaculture cages.

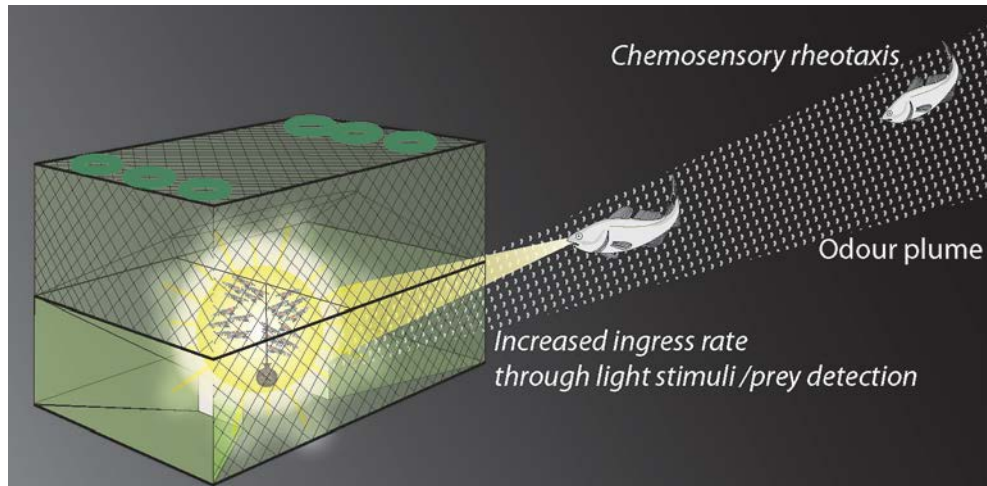


Figure 16. The principles of using light as an attractor in fish pots.

12.6.9 Use of artificial light in Basque fisheries (Luis Arregi)

Among the Basque fisheries there are only two fishing techniques that use artificial lights for fish attraction; the purse-seine and the jigging handlines operated by artisanal boats. The target species for the latter are squids (*Loligo forbesi* in summer and *Loligo vulgaris* during autumn and winter). While the fishing seasons for purse-seiners is March to June in the mackerel, anchovy and sardine fisheries and November to December for the horse mackerel and sardine fisheries. In the Basque Country there are around 60 purse-seiners and a high variation in the number of jigging artisanal boats depending on the abundance of squid, but never exceeding 25 boats. Purse-seiners can attract the fish with lights by themselves or they can use a small boat with lights and then set the seine around them. The lights more frequently used in both fishing techniques are incandescent lamps, set on the surface. There have been some concerns about energy use in these fisheries and regulations exist in an effort to control this: there is a limit of one auxiliary (light) boat per fishing vessel and there is a 6kW limit on light power (in the Mediterranean).

12.6.10 Artificial light, increasing catch in cod pots? (Sven Gunnar Lunneryd, Sara Königson and Mikael Ovegård)

In the southern Baltic Sea, the gillnet fishery targeting cod is suffering due to severe net damage from seals. A project has been developed working with fishers to try variations of cod pots in an attempt to develop a gear where the seal cannot access the catch. Two fishers in the southern Baltic were engaged, one full-time and one part-time, who tried variations of cod traps and simultaneously documented the catch. An innovation by the fishers was to include an artificial light in the pots; a small light "TYPE-100" emitting a steady green light. Four lights were deployed randomly in each fleet of eight pots of the floating Norwegian two-chamber design. About 250 pots were deployed with lamps and an equal number of controls by each fisher. In the western region, the catch of cod, larger than 38 cm, was doubled using the light, 6.13 (5.1–7.2 95% CI) number of cod/pot compared with 3.09 (2.5–3.7 95% CI) in the control. The corresponding figures in the Eastern area were 1.34 (1.2–1.5 95% CI) and 1.09 (0.91–2.0 95% CI); a 22% increase in pots with lamps. No clear correlation with the catch was found between depth, season (months), lunar cycle or soak time. Only cod were caught in the pots. It was concluded that the green light increases the catch of cod in the pots, but the causative mechanism is unclear. Is it the

cods' attraction to the light or is the light attracting some prey for cod? If pots are to be used in the coastal fishery in the Baltic, artificial light has the potential to increase of the catch per unit of effort and hence profitability of the pots. The economic threshold for the profitable use of lights in pots was estimated to be ~1.5 Euros/kg of cod.

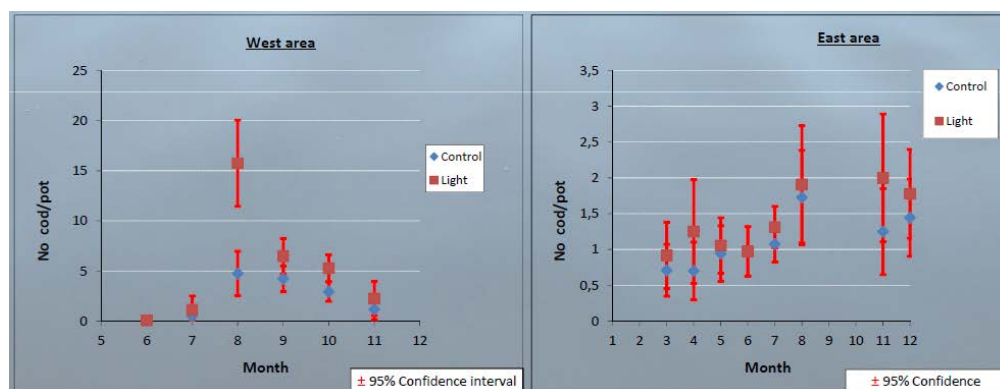


Figure 17. A comparison of cod catches in pots, with and without (control) lights, in two different areas of the Swedish coast.

12.6.11 The use of artificial light in fisheries in the USA – (Pingguo He).

There are few examples of artificial lights being used in fisheries in the USA. There has been some experimental work using light for fishing for squid, but this work was inconclusive on the east coast (Amaral and Carr, 1980). While it was more successful on the west coast (Mercer and Bucy, 1983), it has not been developed as a commercial technique or fishery.

Discussion – the current challenges in the use of artificial lights in fisheries

Legislation – bans and controls on light use.

A number of the presentations identified that the use of light in many countries is controlled, or even banned, by legislation; for example:

- Japan – regional bans on use of light and limits on power output;
- Korea – light banned from inshore fisheries and limits on power output;
- Norway – ban for sprat fishery in Skagerrak because of bycatch of cod and north of 62°N latitude;
- Spain (Mediterranean): limits on power output
- Sweden – “It’s complicated!!”

The main reasons for this appear to be due to conflict between or fisheries and gear types, as well as concerns over excessive power usage. Indeed, with respect to the latter point, there are examples from Asian fisheries where fishers (with smaller, lower power vessels) have requested government/legislative intervention to allow for fairer competition between vessels within the fleet. It is clear therefore that any future initiatives in the use of artificial light in fishing will also need to address legislative barriers, as well as the potential conflicts underlying the legislation.

Energy usage

It may be argued that the innovative use of light in fishing may lead to the reduction in energy usage by enabling the economic replacement of trawling with more fuel efficient alternative techniques. However, a number of the Asian delegates emphasized the conflict and acceleration of energy usage that can arise following the introduction of light fishing. The key driver for this problem is fishers simply attempting to outcompete each other with respect to light output, and therefore their ability to attract fish. If unchecked, such behaviour can also lead to overfishing. While some fishers in Asia have called for legislation to further limit power output from light fishing vessels, others have individually reduced their own power usage, and hence running costs, by avoiding other vessels.

Another solution is the introduction of low energy light sources, e.g., light emitting diodes (LEDs). LEDs have a number of advantages over conventional lamps. Their low energy usage means they have low operational costs; moreover they have a long operational life and contain no hazardous materials (e.g. mercury). They can also emit most wavelengths of light, over a narrowband wavelengths and in a highly directional beam (An and Matsushita, pers. comm.). Thus lamps can be produced which emit only the required wavelengths of light and in the required direction, thus minimizing wasted energy through the use of unnecessary wavelengths, as well as scattering and attenuation of the light. However there are also disadvantages to using LEDs: their narrowbeam can be limiting in some applications and their luminous efficacy is generally less than metal halide (MH) discharge lamps (e.g. MH: 60–130 lm/W; LED: 30–100 lm/W; Matsushita, pers.comm.). Also, although LEDs are cost-effective in terms of running costs, they are expensive to buy (typically 5 times more expensive than metal halide lamps), however the prices are reducing (An, pers. comm.). Moreover wider beam LEDs are also being developed for applications which require a more diffused light beam.

12.7 Session 3 – New and innovative applications of artificial light in conservation-oriented fishing gear designs

12.7.1 Current research on colour and light and its application in conservation-oriented fishing gear designs (Pingguo He)

This presentation gave a provocative review of biological principles and current research in the biology of vision and behaviour that could be used to catalyse innovative developments in the use of artificial light in fishing. Four principal visual characteristics are considered: photosensitivity; spectral sensitivity and colour perception; visual acuity; and motion vision. Visual stimulation using artificial light is assumed to elicit one of three key responses: attraction, repulsion and guiding.

Photosensitivity, light attraction or aversion – prevent or encourage escape? The absence of light has been shown to detrimentally affect the responses of some fish to fishing gear and selective devices (Olla *et al.*, 2000; Ryer and Olla, 2000; Parsons and Foster, 2007). Conversely, the presence of artificial light and/or bioluminescence can increase catches of some species, while decreasing catches in others (Gordon *et al.*, 2002; Weinberg and Munro, 1999).

Visual spectrum: Can coloured gear/bait induce different responses? What an individual sees is the product of the range of wavelengths (or spectrum) of light to which it is exposed and the spectrum to which its retinas are sensitive. Spectral sensitivity can vary considerably between species (Fritsches, 2006; Matsuda *et al.*, 2009). Indeed

some species are capable of seeing ultraviolet light (Fritsches, 2006). Knowledge of the spectral sensitivity of individual species therefore can be utilized to either high-light or camouflage fishing gear, or components of it (Matsuda *et al.*, 2009). Alternatively, species may be particularly attracted or averse to specific colours which could also be utilized for selection; e.g. turtles aversion to blue-stained squid bait (Swimmer *et al.*, 2005), or some species attraction to coloured FADs (Kawamura, 1996).

Visual acuity: Large fish can see better than small fish – a mechanism for size selection? Larger fish generally have better visual acuity and a greater maximum sighting distance than smaller fish of the same species (Arimoto *et al.*, in press). Could these properties be used to initiate size based selectivity during the capture process?

Motion vision: Some fish have higher Flicker Fusion Frequency – can strobe lights be applied? Flicker fusion frequency is the minimum frequency at which flickering images begin to fuse to produce a continuous image (i.e. a movie). Some predatory species have evolved mechanisms to heat their retinas in order to increase their FFF, e.g. swordfish (Fritsches *et al.*, 2005) and bigeye tuna (Brill *et al.*, 2001). Responses to strobe lights have been observed in fish (Patrick *et al.*, 1982; Sager *et al.*, 2000) and invertebrates (Weibe *et al.*, 2004). Therefore, differences in FFF between species could be exploited with the use of strobe lights of a suitable frequency for one species to see flashing light, while the other sees only a constant light (Fritsches, 2006); assuming such differences in perception will also elicit different responses to the strobe. This approach appears to have been used successfully for guiding fish and eels away from the intakes of hydro-power stations (Coutant, 2001; Patrick *et al.*, 1982; Sager *et al.*, 2000).

In summary, with a detailed knowledge of a species' visual capabilities and its responses to visual stimuli, it may be possible to manipulate its behaviour during the capture process thus enhancing the selectivity of that species. Ultimately, it may even be possible to construct a fishing gear almost entirely of light, e.g. the laser trawl (Figure 18).

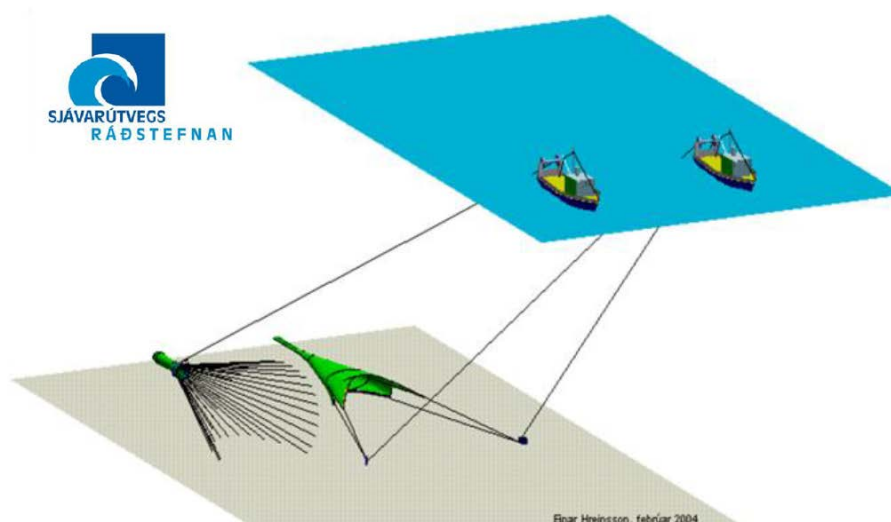


Figure 18. Conceptual diagram of a laser trawl, alongside a conventional trawl (Courtesy of Einar Hreinsson).

12.8 Session 4 – Discussion on the status and recommendations of the Topic Group

The group reviewed the terms of reference and agreed that it would be necessary to address aims 1–3, before aims 4 and 5 could be completed. Therefore, priority should be given to tasks associated with aims 1–3 in the first year of the groups work.

It was agreed that in order to support the activities of the group in addressing these ToRs the group would need to recruit further expertise in each of the following areas:

- physics and measurement of artificial light in water;
- engineering and design of artificial lights, including the development of energy efficient light sources;
- biology of vision, in particular recognition of the natural limits and variation;
- behavioural responses of fish to artificial light; and
- technological application of artificial light in fisheries, including novel and innovative approaches.

Potential candidates were identified and will be contacted.

ToR 1: Describe and summarize fish response to artificial light stimuli

The group identified the following literature reviews that will be conducted in support of this ToR:

- Marine Optics – essential elements for fisheries biology (Y. Matsushita): to provide a background summary to ensure the reader has sufficient understanding to appreciate the properties of light in water and hence the physical limitations of using light in fishing.
- Visual spectrum (retinal pigments) of different species (A. C. U. Palm *et al.*): to provide a background summary to give the reader an introduction to the biology (form and function) of vision in aquatic organisms. This will highlight the limitations of the vision underwater, in particular with respect to their spectral sensitivity, and provide some insight into the perception of light in the underwater environment.
- Behavioural responses to light (S. Løkkeborg *et al.*): The use of light in fishing is dependent upon emitting light (in whatever form) with the purpose of stimulating and manipulating a behavioural response from the target species that will promote their capture. This review will summarize the available literature on behavioural responses in commercially important species, as well as potential prey species.

In support of these reviews, and other associated research, the group has established a database of relevant literature (see Annex 6: A Partial Global Summary of the Fisheries Using Artificial Light).

ToR 2: Describe and summarize use of artificial light in world fisheries

The group agreed that its current knowledge of the status of light fishing is incomplete for most regions of the world, with the exception of the western Pacific and SE Asia. In order to address this ToR, it was agreed that the group would need to undertake the following tasks:

- Identify Regional Correspondents to produce regional reports/overviews of light fishing (M. Breen);

- Produce a summary description of light fishing techniques – industrial and artisanal (tba);
- Investigate the feasibility of using satellite imagery to support a global review of light fishing (e.g. Figure 19. **An example of remote sensing analysis of light fishing in Asia (from Rodhouse et al., 2001)**; M. Breen, B. E. Axelsen, P. He, Y. Matshushita).

This work will provide an overview of the fisheries currently using artificial light as part of the capture technique. It will also describe the fishing techniques currently used in association with light, but will consider the added dimension of “why these techniques and not others?” This perspective, in association with background knowledge of vision, behaviour and the physics and engineering of light, will be used to direct innovative design of new applications of light in fisheries.

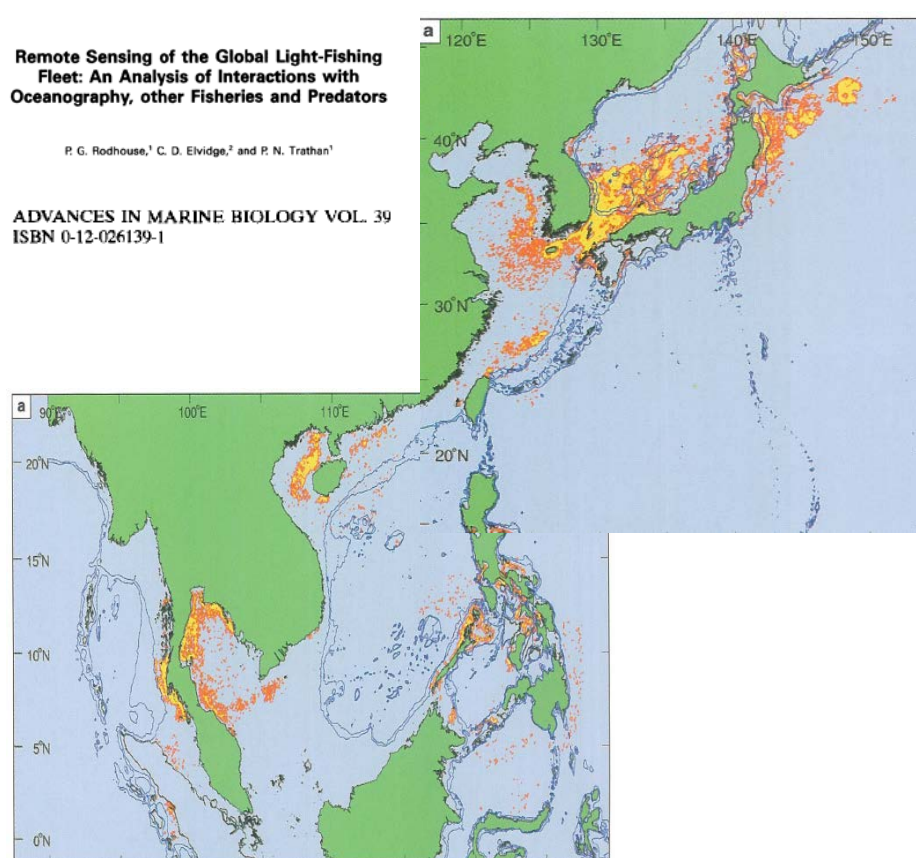


Figure 19. An example of remote sensing analysis of light fishing in Asia (from Rodhouse et al., 2001).

ToR 3: Describe and tabulate different light sources to attract fish

Some data has been, and will continue to be, collected as part of the global review of light fisheries on this ToR (see ToR 2 and Annex 6: A Partial Global Summary of the Fisheries Using Artificial Light). Although some of the presentations did discuss light sources, in particular LEDs, this topic was not addressed in detail at this meeting. Future meetings will examine this ToR in more detail.

In support of this ToR, the group agreed that the following literature review will be conducted:

- A technical review of the sources of light applicable for use in fisheries (H. C. An): to provide a background summary to give the reader an introduction to the available and emerging technologies for the production of light. The advantages and limitations of using the different technologies in fishing will be highlighted.

ToR 4: Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions

This ToR was addressed to a small degree during the discussion in session 2; where the excessive use of lighting power and subsequent legislative restrictions on the use of light for fishing were seen as two of the major challenges currently facing this sector. However, it was recognized by the group that this topic could not be addressed properly until it had a more comprehensive global overview of the light fishing sector.

ToR 5: Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods.

Pingguo He's presentation in session 3 made a very constructive start to addressing this ToR. It was agreed by the group that the issues addressed in this presentation would provide a useful template on which to progress the work. Therefore in conjunction with the reviews detailed in ToRs 1–3, it was suggested that work could progress with a more substantial literature review:

- Innovative Use of Light in Fishing (P. He *et al.*): to provide a review, complementary to the review on the behavioural responses of commercially important species to light (ToR 1), with the purpose of providing guidance on the constructive, selective and innovative use of these behavioural responses/manipulations in the fish capture process.

ToR 6 (Additional): Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture

The group felt that due to the multidisciplinary nature of this work it would be beneficial to provide guidance on protocols for conducting and reporting experimental work, in particular: the correct technical specifications for the light sources; the protocols for measuring of light; and the most important environmental parameters to be monitored, with respect to the transmission of light (see session 1 discussion). The following tasks were identified:

Task – Review light measurement protocols and instrumentation requirements (M. Breen, O. B. Humborstad, H. C. An and Y. Matsushita)

Task – investigate the feasibility of establishing common facilities for the measurement of light irradiance and transmission (M. Breen)

12.9 Recommendations

The ICES/FAO WGFTFB Topic Group on the Use of Artificial Light in Fisheries makes the following recommendations to the ICES/FAO WGFTFB:

- 1) The Topic Group on the Use of Artificial Light in Fisheries should continue working by correspondence and meetings (at next WGFTFB meeting) under amended terms of reference (see below);

- 2) It is proposed a theme session should be held at the next ICES/FAO WGFTFB meeting on “the use of artificial light as a stimulus on fish behaviour in fish capture”; and
- 3) The Topic Group supports the proposal for the next WGFTFB meeting to be held in Asia. This venue will facilitate the development and work of this group, by opening lines of communication with experts in Asia currently working in the field of light fishing.

Amended Terms of Reference

A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions.

Specifically the group aims to:

- *Describe and summarize fish response to artificial light stimuli;*
- *Describe and summarize use of artificial light in world fisheries;*
- *Describe and tabulate different light sources to attract fish;*
- *Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions;*
- *Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods; and*
- *Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture.*

Discussion

The ALTSTIM project was mentioned, a report is available (bob.vanmarlen@wur.nl).

13 ToR D: Innovation in Fishing Gear Technology (Bob van Marlen)

13.1 General overview

The topic group met on 25 and 26 April 2012 in Lorient, France. A total of seven presentations were given on various innovative developments on: Innovative Fishing Gears in The Netherlands; An energy efficiency analysis for Italian fishing vessels through an Energy Audit tool; the Swedish Grid; Gear innovation to reduce cod capture in the Scottish Nephrops fishery; The prediction of the vertical forces applied on the seabed by a trawl gear; the effect of introducing pulse trawling in North Sea fisheries on a range of fish major target species; Innovative Low Impact and Fuel Efficient (LIFE) fishing practices; and a demonstration was given of the software DynamiT of Ifremer. The various aspects of innovation were thoroughly discussed. It was expressed that this Topic Group should not be continued next year.

13.2 Terms of Reference

The group met under the following Terms of Reference:

- 1) Review current technological developments and initiatives in gear technology and give examples of successful developments both in the EU and in other countries globally;
- 2) Discuss the contributions of fishers and scientists in the process of collaboration and identify conditions enabling rapid uptake of new technology, without the risk of introducing new adverse ecosystem effects;
- 3) Consider the use of models with which the effect on the marine ecosystem (concerning target species, fish and benthos bycatches, bottom impact) of introducing new innovative gears in fishing fleets can be appraised.

13.3 List of Participants

Name	Institution	E-mail
Simon Armstrong	Cefas, Brixham, England UK	simon.armstrong@cefas.co.uk
Luis Arregi	AZTI, Sukkarrietta, Spain	larregi@azti.es
Gerard Bavouzet	Ifremer, Lorient, France	gerard.bavouzet@ifremer.fr
Daragh Browne	BIM, Dun Laoghaire, Ireland	browned@bim.ie
Tom Catchpole	Cefas, Lowestoft, England UK	thomas.catchpole@cefas.co.uk
Arill Engås	IMR, Bergen, Norway	arill.engas@imr.no
Einar Hreinsson	MRI, Reykjavík, Iceland	eihreins@hafro.is
Bjoernar Isaksen	IMR, Bergen, Norway	bjoernar.isaksen@imr.no
Ludvig Krag	DTU-Aqua, Hirtshals, Denmark	lak@aqua.dtu.dk
Bob van Marlen	IMARES, IJmuiden, Netherlands	bob.vanmarlen@wur.nl
Bernd Mieske	VTI Rostock, Germany	bernd.mieske@vti.bund.de
Hans Nilsson	SUAS-IMR, Lysekil, Sweden	hans.nilsson@slu.se
Barry O'Neill	MSS, Scotland UK	oneillb@marlab.ac.uk barry.o'neill@scotland.gsi.gov.uk
Daniel Stepputtis	VTI Rostock, Germany	daniel.stepputtis@vti.bund.de
Francois Theret	Scapeche SA, Lorient, France	ftheret@comata.com
Petri Suuronen	FAO, Rome, Italy	petri.suuronen@fao.org
Benoit Vincent	Ifremer, Lorient, France	benoit.vincent@ifremer.fr

13.4 Opening of the meeting

Bob van Marlen opened the meeting. Participants briefly introduced themselves. Daniel Stepputtis volunteered to act as rapporteur.

13.5 Adoption of the agenda

The agenda was adopted with some changes.

13.6 Individual presentations

13.6.1 Innovative Fishing Gears in The Netherlands (Bob van Marlen)

Attempts to improve fishing gears are not new. It has always been part of the research agenda in Europe, in the 1970's aimed at improving catch and mechanical efficiency of fishing, in later decades aimed at reducing unwanted bycatches and seabed impact. Dutch R&D resulted in new large mesh pelagic trawls in the 1980s and species selective beam trawls in the 1990s. Since 2008 the Dutch Fisheries Innovation Platform stimulates the development of innovative energy saving fishing gears in the Dutch fishing fleet. This approach has led to higher motivation in the industry and some new remarkable fishing gears being used to a growing extent. Examples from the Netherlands are: Pulse Trawl and Pulse Wing, SumWing, Outrigger, HydroRig, and Large Mesh Top panel in beam trawls, and Large Mesh front section in pelagic trawls. The energy saving potential and ability to address ecosystem concerns (bycatches and bottom impact) of these gears are discussed. Savings up to 50% in fuel costs and improvements up to 80% in net revenue can be achieved in beam trawling.

The session is aimed at making an inventory of recent developments and identifying success factors for innovation.

Table 2. Fishing gear innovation procedure explained.

Step	Fishing gear innovation procedure
	Activity
1	Define objectives
2	Design new gear
3	Test model in a flume tank
4	Test full-scale prototype on FRV
5	Test full-scale prototype on commercial fishing vessel
6	Evaluate ecosystem and economic effects
7	Back to step 2 if needed
8	Introduction in fishing fleets

Table 3. Drivers, actors and barriers mentioned.

Drivers	Actors	Barriers
Cost (fuel)	NGO's	Legislation
Salaries	Manufacturers	Low fish price
Market demands	Scientists	
Legislation	Fishers	
Social pressure	Fishermen's organizations	
Sense of ownership	Banks	
Communication strategies	Retailers	
	Consumers	
	Certification organizations	

Table 4. Updated summary of motives and level of uptake.

Modification	Gear type ^a	Motive(s)	Level of use
Pulse Trawl and Pulse Wing	TBB	Bycatch ↓, fuel costs ↓	+++++
SumWing	TBB	Fuel costs ↓, impact ↓	++++
LM	OTM	Fuel costs ↓, catch ↑	+++
Outrigger	TBB	Fuel costs ↓	+
HydroRig	TBB	Bycatch ↓, fuel costs ↓	-
LMTP	TBB	Bycatch ↓	-

^a OTM = Otter Trawl Midwater; TBB = Twin Beam Bottom; LM = Large Mesh; LMTP = Large Mesh Top Panel



Figure 20. Pulse Wing.

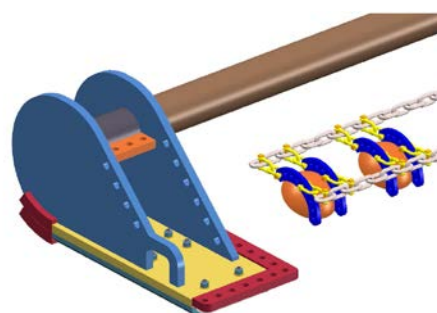


Figure 21. HydroRig.

Conclusions are:

- Success of introducing new selective, low impact and fuel efficient gears depends very much on strong (economic) incentives for fishers to use them. Sharp rises in fuel prices, threats of closing areas when selective gears are not used enforcement by law, and fish products losing markets if not caught in a sustainable manner are all strong incentives.

- Saving energy coincides well with reducing seabed impact and bycatches, as gear components are designed with less bottom contact and releasing unwanted bycatches avoids the need to drag these inside the net and bring these aboard.
- It helps when fishers identify themselves with potential solutions, instead of being told what is good for them, and involving them more directly in identifying research needs and setting up projects leads to higher motivation and acceptability. In addition there is a need for financial support of experiments.
- Scientists and fishers should preferably work closely together to create sustainable ecosystem friendly technologies and practices. Cooperation between fishers and scientists needs to be stimulated, with emphasis on open-minded attitudes on both sides.

Discussion

Static gears were not mentioned here, but a project was also done with three vessels using gillnets, pots and jiggers. There were many discussions in the Dutch fishing industry about fuel consumption and ambitious targets to reduce this by 2020 have been set.

ToR D is to learn about how innovation can be achieved and the role of science in it. In the EU there has been no real pressure to change anything for a long time. With increased incentives our role will change, *e.g.* as mentioned when a discard ban will be issued. Also many innovations we have suggested were not taken over by the industry, but the demand has increased recently. We should realize that we are not the only driving force, and that good platforms are needed to bring fishers together. Some expressed the view that scientists should change their role. In many projects scientific evaluation is needed. The example of the Dutch Fishermen Study Groups (called: 'Knowledge Circles') was deemed a good idea, and this attracted interest in other countries. The work under the phrase: "for fishermen and by fishermen". The basis of many project is short with often a 3 year term, this may not be long enough.

It was commented that during the development of pulse trawling too little information was collected to conduct a real assessment of impacts and advantages and nevertheless many vessels have been given a license to use this method. Also interest for participation in SGELECTRA was expressed from Ireland.

The group felt that the scientific community should have a role in facilitating and evaluating innovation in the industry, but also can act as innovators itself. Then the industry needs to be given the chance to identify with a problem, and if so will ask the scientists for a solution.

An advantage this group has is that we can synthesize knowledge from all over the world, which fishers in most cases do not have. But on the other hand we should be open-minded and realize that we can also learn from what is going on in the industry. Fishers often change gears too quickly in experiments; it takes time for them to learn about the requirements for reaching scientific rigidity. It is often better to leave the choice to the fishers, and not to impose choices on them. A bigger mesh size is often the easiest solution, preferred by fishers, instead of more complex devices they have to install in their nets. Trust building and communication are important, *e.g.* involvement in stock assessment surveys by fishers might help to create mutual understanding, and examples of this in the Netherlands were given. Similar experience in Sweden was reported, with outcomes of surveys by fishers equalling the results

found by the scientists. But the experience shows also that trust can be lost very quickly. This group is often associated with restrictions fishers experience from *e.g.* quota settings and other regulations. It is also wise to bring in fishers early in the innovation process.

Industry took over many developments started by scientists, *e.g.* large meshes in Norwegian and Dutch pelagic trawls. It is important to stress that we are working for the future of fishers. Often the reaction is: we don't need what you suggest. It is recommended to make contact to the real innovators in the industry, there are differences in attitude in each group, and in any industry one deals with people who see a need for change and those who prefer not to take any risk and wait. New technology is often deemed as being misused by fishers, which hampered financial support, *e.g.* from the EU over many years.

GHG emission caps will become more stringent, it happens in the merchant marine right now, and will occasionally be asked of the fishing industry also.

The link to economy may not be only direct factor; costs associated with global warming may be much larger. The benefits might not go to the fishers addressing these topics. These diseconomies are not (yet) taken in the price of fish.

Our job has two aspects, a short term and longer term one. Projects are often short in duration. Results are often for a small group of fishers, scientists may be restricted in spreading out information.

13.6.2 Energy efficiency analysis for Italian fishing vessels through an Energy Audit tool (Antonello Sala, Gabriele Buglioni, Emilio Notti)

At least since we learned to admit that crude oil reserves are limited, improving energy efficiency has been regarded important. Recently the climate effects of exhaust gases from combustion processes have been increasingly focused. This is underlining the importance of improving the energy efficiency in all sectors in which are currently depending on the use of combustion engines, among which we find modern fisheries. The actual fishing fleet, in most cases, is not efficient because of outdated technology. Nevertheless there is no question fuel consumption in fisheries can be reduced and should be a directive of fisheries regulators. There are new technologies and products available that can reduce fuel consumption and lower exhaust emissions. New fishing vessels have a great efficiency level, compared to the actual state-of-the-art. Over the years the energy efficiency of the ship goes down due to obsolescence, while that of the state-of-the-art rises. Maintaining an adequate level of energy efficiency requires a continuous monitoring of the vessel's energy profile through a methodological measurement approach. Any cause of energy inefficiency can be identified, and thus acted on promptly and effectively. An energy audit tool is therefore essential to maintaining high energy efficiency of the vessel. With an energy audit it is possible to evaluate the energy performance of fishing vessel under different operating conditions. Once energy consumption has been related to each operating condition and speed, fishers can modify fishing operations to minimize fuel consumption, through energy audit which allows obtaining an extensive energy profile of the fishing vessel monitored. The energy profile is defined through Energy Performance Indicators, so that comparisons between different vessels are possible.

The system consists of flowmeters, torque and shaft r.p.m. meters, an ammeter, strain gauges, GPS, and a gear monitoring system, connected to a data logger. Gear drag and thrust are determined. Propeller characteristics are often not known by the fishers in Italy. Energy and fuel consumption indicators are used. The pelagic boats take

more power than the bottom-trawlers. A number of follow-up activities improving energy consumption were mentioned. If you can show benefits fishers are interested. The typical age of boats in Italy is old, 20–30 years, and therefore efficiency is problematic. A strategy is needed to come to proper solutions. Use of ducted propellers in bottom trawlers is advocated. A small reduction in steaming speed of 11 to 10 knots may save as much as 20%. Project ICEEF was brought to the attention of this group. A list of terminology in different languages is also on the project website, and private initiatives are linked to.

Discussion

Is there a sense of urgency? Yes, there is an economic urgency. Engine power control can be helped using this audit. Fuel meters are used more and more and fishers react to them. A Good Environment Status (GES)-like system is not used yet. The audit has no prediction element, but gives a picture of reality. Contacts with fishers came from regular gatherings at the laboratory that happen on Fridays. One has to improvise now and then; the system may be shut-off at times, when fishers do not feel comfortable. Landings and economic benefits could be added to the system. Revenues are not yet taken in, this would require a number of years of data collection as catches fluctuate. Sensors are auto-calibrated; in other cases the relation between measured value and reality is known. There is no need for frequent calibration. The torque meter gets special care. There is a good feedback from the skippers, who also suggest improvements, and ask for reports. Work with one fisherman when you introduce an innovation, others will follow, instead of trying to address a whole group, as they will behave differently in a group. Experience in France shows that it is difficult to compare vessels as calibrations may differ, hull shape, length, engine and gear may be very different. Increasing vessel power is often regarded as suspect. Economic certification on fuel economy is starting up in France. A total of 60–100 boats will be tested. The thrust on the propeller is of vital importance, and the drag of the fishing gear. Biologists only speak of vessel power, and seem to ignore gear characteristics. Trawls are often not well rigged. It is important to not only look at the net drawing, but take experiences of skippers onboard too in direct contact. It is also wise to involve net-makers in the process. Otherwise time is lost.

13.6.3 The Swedish Grid (Hans Nilsson)

Start of the development was the TV-program, titled “The last cod” in 2001, followed up by the green-party wish to stop the Swedish cod fishery in 2002, in which cod was a bycatch. In 2003 the problems were identified, and Pandalus, and Nephrops fisheries addressed. The idea was to move the trawl border out and allow fishing only using grids inside the coastal area. The bycatches in the T1 fishery, with 90–99 mm meshes were substantial, up to 70%. The Swedish grid was tested in 2002–2003 by the National Board of Fishery (in the EU NECESSITY-project). The trawl (70–89 mm mesh) with a grid had much cleaner catches. The uptake of the sorting grid was about 54%, and the use of the conventional trawl went down. The next step was the VIDREST size selective sorting grid, developed in 2008 for releasing small Nephrops. The bar spacing in this grid varied from 22/35 mm, with a 70 mm square mesh codend. For commercial purposes 22/40mm spacing with 70 mm square mesh was taken, and for grounds with flatfish 22/40mm spacing with 90mm diamond mesh. Pairwise experiments using a twin-trawl were done. The result was that small Nephrops were effectively selected out by ~50% compared to the standard grid, and more larger individuals were taken, especially at higher carapace length, bringing the best prices in the market. For cod no real difference was found, just a little bigger fish

were found in the catch. Small dab and American plaice were released to a large extent too in the Kattegat, especially in the diamond mesh trawl.

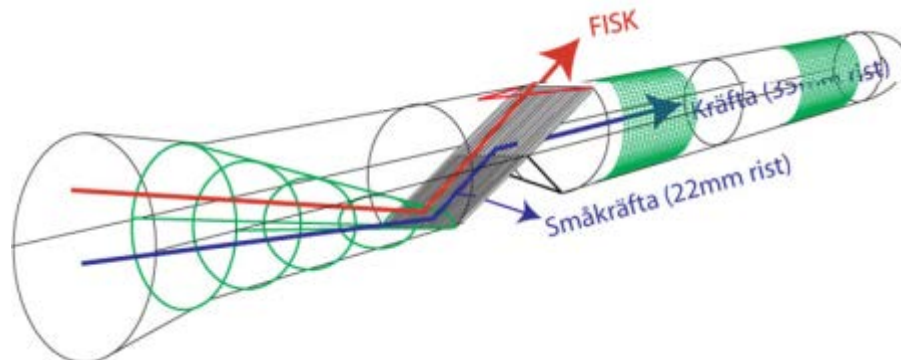


Figure 22. Swedish size selective sorting grid in Nephrops fishery.

Lessons learned: cod catches still comprise 1.5% of landings and discards. Good documentation is needed to prove this, related to Article 11 in the Regulations. In discard data collection the equipment used is not always recorded correctly.

Discussion

The experience in the UK is that the Swedish grid is always pushed by the Commission. It is used with the square mesh codend, and only 70mm square mesh can be used. With 80 mm diamond mesh fish and small cod are still retained. When cod stock recovers in the Kattegat there may be a problem with the 90 mm diamond mesh. Perhaps different mesh sizes in the top and bottom. Most boats are small (L ~15m) and do not have much crew: decreasing sorting time is an issue. The combination of square mesh for cod and diamond mesh for flatfish remains cumbersome. It also depends on whether the fishers have a quota for cod. The shrimp fishery in Sweden does still catch a lot of cod; this will be changed with the discard ban next year.

13.6.4 Gear innovation to reduce cod capture in the Scottish Nephrops fishery: the flip/flap and FCAP trawls (Barry O'Neill).

The Flip/Flap Netting Grid Trawl (FFG) and the Faithlie Inclined Panel Trawl (FCAP) have been developed by two different Scottish netmakers to reduce the capture of cod in the Nephrops trawl fishery. Here we report on some of the trials carried out by the Scottish Fishermen's Federation and Marine Scotland Science to compare the selective performance of these new gears with that of the standard Nephrops gear used in the Nephrops fishery.

The FFG comprises of 160 mm in the top sheet and wings (instead of 80 mm), a flip/flap netting grid and 200 mm Square Mesh Panel (SMP) in the top sheet (Figure 23). The vertical panel of 200 mm netting is attached to the top, with the lower half hanging freely down in the water flow using weights. This gear was not directly observed. Catch comparison twin-rig trials were done in Jul-Nov 2011 on MFV "Sardonix II" (375 kW). The results for the FFG show a large and significant decrease in the number of the three main whitefish species retained. The reductions by weight of cod, haddock and whiting are 73, 67 and 82% respectively. Nephrops catches were very similar for each gear and there is a weak suggestion that fewer monkfish and

megrim were retained by the FFG gear. Further details can be found in Drewery *et al.* (2012).

The FCAP was rigged in a Nephrops trawl and a so-called 'letterbox' trawl (a wide net with low height). It is built of an inclined panel inserted inside the trawl, 8 * 14 squares, 200 (12") mm in 80 mm surrounding mesh. The meshes in the lower part were cut out. There are two triangular fish outlets in the top panel where the inclined panel ends, of 15 meshes wide. The results for the FCAP indicate that this is also a very selective gear and demonstrate that there are reductions of between 70 and 80% of cod in comparison to the control gears used. Further details can be found in Jones (2012).

References

- J. Drewery, M. Watt, R. J. Kynoch, A. Edridge, J. Mair, and F. G. O'Neill, 2012. Catch comparison trials of the Flip Flap Netting Grid Trawl. Marine Scotland Science Report 08/12.
- Jones L., 2012. Catch Comparison Trials Using a Faithlie Cod Avoidance Panel (FCAP) In a Faithlie Low Headline Letterbox Trawl and A Standard Nephrops Trawl. SFF report.

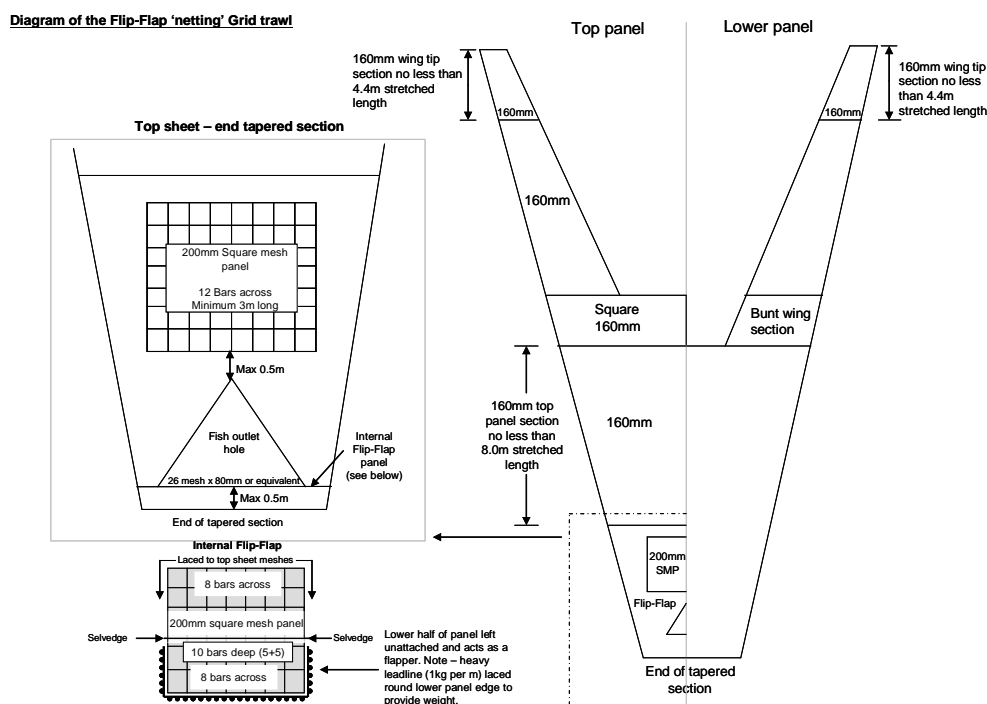


Figure 23. Scottish Flip/flap gear.

Discussion

The Flip/flap is an option that is allowed for use, the inclined panel may also be used, and is much cheaper to install. The development came from the industry; they could get a reasonable number of days for use. They did not want a grid. A reduction of 60% in cod can be obtained. The existing restriction of 100 Days-At-Sea (DAS) can go up to 200 DAS, if they can reduce cod by 60%. The designs were made by the industry; Marine Science Scotland gave scientific guidance. No blockage was found, although the panel was vertical. The towing speed was about 3 knots.

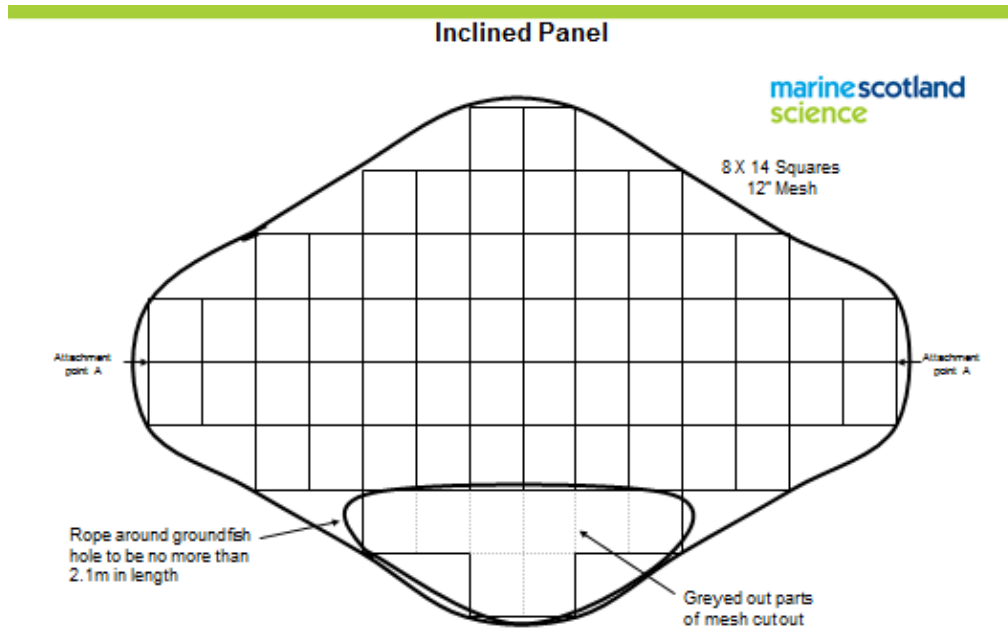


Figure 24. Scottish FCAP gear.

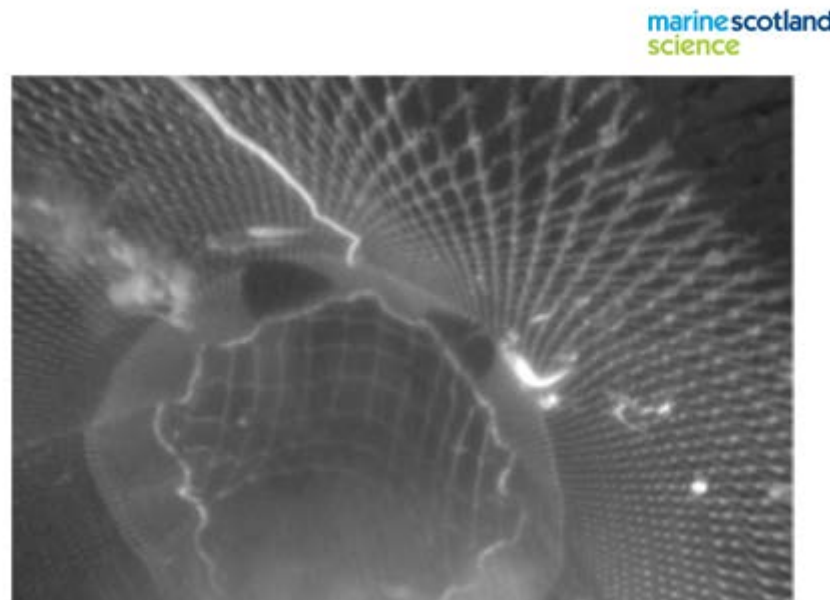


Figure 25. Underwater footage of Scottish FCAP gear.

In the FCAP net twine thickness was 3–4 mm. Cod tend to stay low inside the net. Same issues were met in the English Nephrops fishery, a discussion will be held next week, possibly followed-up by sea trials. The flip/flap idea might be taken used. The retention of smaller fish is better than of larger fish. The Inclined Panel might be preferred, because it is easy to install. Observations showed that fish went through the

escape hauls. In the FCAP net monkfish could get stuck in the panel, shown by video. The difference between the SFF and MSS trials was large.

The SELTRA-design is put forward in DK for the Kattegat, with 180 mm mesh, and the height needs to be controlled. Mike Montgomery will be testing a Swedish grid. Contact was made through SFF, the designs were made entirely by the industry, by individuals (netmaker). Flume tank models were made for the FCAP and tested in Hirtshals with SEAFISH involvement. They have 6 weeks in the tank per year. The designs got more acceptance, because they were made by the industry. There was a clear incentive to reduce bycatches of cod by 60% and get double the DAS. As they have no quota to land cod, there was no opposition against releasing the bigger ones. The difference between the SFF and MSS trials was large because of gear problems. The focus was to reduce the weight of cod caught by 60%, and not on optimizing size selectivity.

13.6.5 Prediction of the vertical forces applied on the seabed by a trawl gear (Francois Theret).

Ifremer's DynamiT™ software is used. The forces on the seabed can be calculated on each node, as resultant of weight, drag lift, and twine tensions. Forces from the seabed are composed of one vertical force using Coulomb's friction law, and are not depending on the towing speed. Penetration in soft sediment and sediment removal or suspension are not taken into account. It can be done in DynamiT without alterations. A simulation was shown in DynamiT. The depth of the gear can be changed (e.g. by 0.5m), than the time determined that the gear is off the seabed. Drag is taken at 60% of the vertical force. Frictional drag can be more than 10% for an otter trawl.

Discussion

The door roll angle can be varied, but not the heel angle. Otterboards can be easily rigged to fly off the seabed completely, as found in the EU DEGREE-project. DynamiT has 50 licenses sold worldwide, at 8200 € each, it is used by many netmakers. The 'Jumper' door was developed to stay close to the bottom, but is not used yet in the industry. A new version will be developed. The door 'Jumper' uses a lot of space on-board, and because of its light weight, it takes more time for shooting the gear. New doors have better hydrodynamical shapes generating smaller sand clouds, but are nevertheless used to a great extent. The development of the DynamiT program started in 1991, and the first commercial version came out in 2000. A successor is under development, not only for trawls, to be expected in about three years.

13.6.6 The effect of introducing pulse trawling in North Sea fisheries on a range of fish major target species (Bob van Marlen)

The model developed by Piet *et al.*, 2009 was used. It is based on métiers of fleets in the countries around the North Sea, and uses a baseline of effort and abundance data of 2006. Three major gear groups are in the model: beam trawls (TBB), otter trawls (OTB) and static gear. In the model new overall gear efficiencies and towing speeds are used to appraise the effect of changing tickler chain beam trawls into pulse trawls in the relevant métiers. Under the assumptions of the model relatively large reductions were found in landings and discards of the five major target species addressed, i.e.: COD, HAD, PLE, SOL, and WHG. Further work will be carried out in EU project BENTHIS.

Discussion

Cefas is working on similar models. There are plans to extend the model, but data need to be grouped in broad categories. There are many assumptions in this model, such as gear widths (OTB), and herding effects of gear components. It is difficult to validate such models. Survey data will be used and observer data to a larger extent. These models require a lot of data. The new EU BENTHIS-project will elaborate of this approach. There is lack on information on gear parameters to calculate area fished especially for OTBs.

Table 5. Percentage change in landings and discards in all gear groups when pulse trawling is introduced in the relevant métiers.

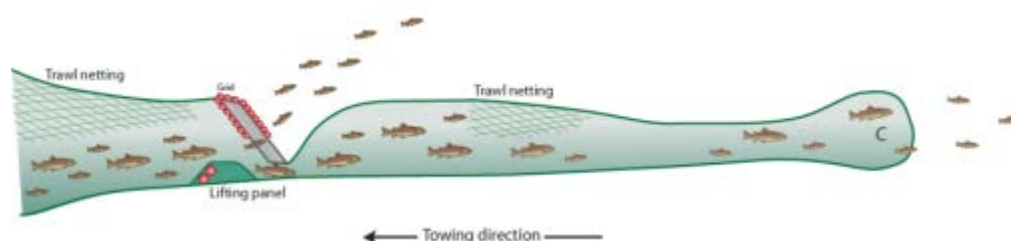
Species	% LAN All	% DIS All
COD	-11.2	-28.1
HAD	-8.1	-6.5
PLE	-16.3	-39.3
SOL	-7.0	-23.9
WHG	-38.5	-54.8

Economic effects should also be taken into account, *e.g.* due to changes in Days-At-Sea (DAS). An economic analysis was also done in EU project NECESSITY showing short-term losses in income from having more selective gears.

13.6.7 Innovative Low Impact and Fuel Efficient (LIFE) fishing practices (Petri Suuronen).

There is a need for innovation. Fishing has impact on the environment depending on gear types. Passive gears cause less damage than active gears, but effects depend on the use, and thus are relative. Be careful therefore with ranking gears in terms of effects, and adding labels. Most fishing is heavily dependent on fossil fuels. A total of 41 M tons are consumed by fisheries. The price of fuel has been as high as 130 USD per barrel, and there is general consensus that it will likely continue to get higher. The global average of fuel consumption per unit of fish landed is 0.6 L/kg, and a total of 130 M tons of CO₂ are emitted into the atmosphere by fisheries, big enough to become an issue. Passive gears contribute 0.1–0.3 L/kg, and active gears 0.5–1.5 L/kg, while purse-seines consume 0.1 L/kg. The midwater trawl at 0.2 L/kg is rather efficient. Light fishing also uses a fair amount of fuel. There is a paper published about LIFE fishing in Fisheries Research. Ways to reduce fuel consumption are presented, among which are: better design, materials and rigging of trawl gears, adjusting the weight of trawl doors and groundgear by instrumentation (smart-trawling), use of acoustic, light, electric pulses and other stimuli to enhance the encounters by target species, use of real-time monitoring and control systems in the trawl (acoustic and camera technology), avoidance of sensitive bottom habitats with the help of seabed mapping tools and integrated GPS systems, reducing towing and steaming speed, and affecting human behaviour and skipper decisions. Comments to this list are welcomed. Tradition is strong and gear changes are usually slow. Mixed species bottom trawling may not be maintained. There seems to be a future for the further develop-

ment of passive gears such as: pots, seines, traps, trapnet, gillnets. Thus there is a need for much more work. It is difficult to get fish in a trap. The bycatch issue of sea-birds was also mentioned. Gillnets can also be damaging, and care should be taken to list them as only good. Why should fishing practice be changed? Energy costs are getting too high, and there are no suitable alternative sources. For instance, bio-diesel is a conflicting issue. Techniques that increase work and costs are not willingly adopted by the fishing industry. Fuel subsidies may work against energy-efficiency, and are still widely given. There are many barriers to transition into LIFE-fishing, also barriers in human behaviour. Incentives are needed to achieve change. For further uptake of passive gears the fish stocks should perhaps be in a better shape. Excessive use of any gear type may cause overexploitation and significant ecosystem impacts.



Conclusions

- Each fishing gear and practice has advantages and disadvantages.
- Suitability of each gear largely depends on fishing area and species.
- Optimal solutions vary among fisheries.
- Success of transition to LIFE fishing will depend heavily on:
 - developing acceptable technology
 - creating appropriate incentives for change.
- Rigid regulatory regimes can hinder fishers' efforts to innovate and adopt new technologies.
- Close cooperation between fishing industry, fisheries managers, scientists and other stakeholders will be necessary in developing and introducing cost-effective and practical LIFE technologies.
- Global research and development priorities should be established to support the development and uptake of LIFE fishing.

Discussion

Bottom seines may also have a considerable impact contradictory to the general belief. Reducing towing and steaming speeds should be added. The EU ESIF project showed that operational profiles are important. An organization of debate is needed, *e.g.* the Dutch example of the North Sea Task Force and Fisheries Innovation Platform. When the need is there then changes may happen quickly, and a real difference is made. In the Netherlands 50% of fuel costs could be saved in just a number of years. Computer aided design should also be promoted. Do not forget that other fuels such as LNG may come into the picture. Look at other sectors of shipping, *e.g.* tug boats. Increasing efficiency of fishing gears is also a way to address this LIFE fishing concept. The comment was made that pots are forbidden in Spain, strangely enough. The recent uptake of pots in Canada is significant.

13.6.8 DynamiT demonstration (Benoit Vincent)

A demonstration of input of net panels and materials in DynamiT was given for a bottom trawl. Asymmetrical sections can also be put in, with cutting rates, or numbers of meshes. Ropes can be put in to be attached to netting panels, and floats or weights. Then the connections are defined and the connection to the rigging. Doors are defined by surface area, mass, hydrodynamic coefficients, and roll angle. Warp attachment points to the boat are also put in. The software works with virtual meshes that can be varied in size and represent a number of real meshes. Then net drawings can be made, information can be added after copying these in power point. The simulation can then be launched. Swept volume and surface can be calculated. Tensions in the net are displayed in colours, with highest tensions in red. Twine area and total weight data are given in the net drawing. When changes in the calculated values do no longer occur the simulation ends automatically. Also examples of beam trawl designs from The Netherlands were shown, and some help-tools developed by Bob van Marlen in Excel.

13.7 General discussion

The experience in the USA is that fishers may ask payment for data. There seems to be a trend to a bottom-up approach instead of a top-down. But does this always bring the best outcome? Pulse trawling is an example where ecosystem considerations came in when the development was well underway, but does the industry have the expertise? When objectives are well defined, then the industry may work toward it, e.g. reduce bycatches by 50% is an easier objective than making fisheries sustainable.

Should we continue or not? The group felt that there is no need as we seem to repeat things. Some doubling in presentations occurred with the open session, but here we focused on details and there was more time for discussion. It is good to look behind the innovation schemes. How do other nations deal with innovation? Process related presentations are of interest for the open session, e.g. the experience with the Dutch Fishermen Study Groups. The drivers, with social and economic implications are also of interest. A topic group on catch regulation might be an idea for next year.

What have we learned? The industry is sometimes more advanced than we are, they often have other expertise, such as engineering background. How projects are initiated and executed is important. How are they identified? We stepped from liaison groups to initiatives in the industry. It is preferred to contact directly the skippers and not only representatives (such as fishermen's association leaders), as they are closest to actual up-to-date practice. In Norway it was learned that it is important to make sure that there is agreement on what to do, e.g. to define the number of cruises and experiments. Scientific quotas are often used to pay for vessels. Financial compensation is often an issue. In The Netherlands a typical project gets at maximum 350000 € subsidy for a duration of 2–3 years, a call for proposals typically 3 M €, giving room for some 8–10 projects, and these calls are usually over asked. The fishermen study groups is a good idea to transfer to other nations. In France a new project is proposed to save energy on 50 vessels, first monitoring the existing situation. There is also private funding being generated in France to support effort in saving energy and improve selectivity, raised from added levies in supermarkets, and managed by fishers' organizations. Public dissemination is required, but results should not be made identifiable at vessel level. In Spain work is done to split in three vessels classes having their specific problems in what is called technology committees. New projects

can be suggested, the funding comes from the government. Projects can be promoted by the institute or the industry. In Denmark the situation changed a lot the last years, e.g. due to the cod recovery plans. Now there is close cooperation, and initiatives coming from fishers. In Sweden the situation is comparable, the industry comes to the scientists, but also work is done by the industry without scientists' involvement. It depends on the regulations set. A similar situation has arisen in Ireland in the Nephrops fishery related to cod bycatches, with suggestions coming from fishers, often connected through the Internet. Quota taken from the national TAC and set aside for scientific purposes may offer stimulation. Collecting social data by interviews is done in England, to find out driving forces. These are studied to identify the type of solutions required, not necessary of technical nature. Gear selectivity is matched to quota compositions more than just saving juvenile fish. Reducing cod catches by e.g. 60% is an example, irrespective of length. Selectivity profiles may also be targeted in this process.

13.8 Summary of lessons learned in this ToR

- The scene is changing
 - Fishers have PCs too.
 - Fishers use Internet more and more.
 - Awareness of threats exists also in the industry.
 - Industry has own ideas and creativity, and are not waiting for us.
- Good incentives are needed for successful innovation, such as:
 - Cost reductions (fuel price !!!).
 - More days-at-sea (DAS) when using selective gears.
 - Access to fishing grounds only if selective gears are used.
- Fishermen Study Groups (as in the Netherlands) help the process
 - There is more motivation.
 - There is a sense of problem ownership by the fishers.
- Scientists should have a role in innovation.
 - Developments by industry alone may lead to unwanted ecosystem effects.
 - WGFTFB has an international view and wide experience, knowledge of gears, behaviour, statistics, and suitable instrumentation (e.g. RCTV).
- Be aware of group interactions between fishers.
 - It is often better to address a single individual and work with him, others will follow when they see results.
 - Group behaviour is often different.
- Trust building and communication are important
 - Trust is easily and quickly lost.
- Be aware of tension between more efficiency and ecosystem conservation.
 - Businesses need efficiency.
 - Ecosystem constraints and conservation do often not ask for more efficient gears and higher catches.

13.9 Recommendations

WGFTFB recommends that this ToR will not be continued.

14 Open session

14.1 Consideration on Low Impact and Fuel Efficient Fishing: Comparing Squid Jigging and Large-scale fish trap fisheries in western Japan (Yoshiki Matsushita)

Squid fishing has attracted interest worldwide over the last two decades due to its commercial potential under the present condition of targeting species lower down the foodweb. Among the various harvesting methods for squid, jigging with artificial lights (jigging) and large-scale fish traps (trap) are major methods to capture Japanese common squid *Todarodes pacificus* and swordtip squid *Photololigo edulis* in western Japan. Jigging is a highly selective fishing method that consumes large amounts of energy for steaming and lighting. In contrast, traps are a low energy fishing method but its catch is influenced by environmental factors due to its immobility.

We analysed squid catch of one fishing community in Nagasaki which operates both fishing methods (64 jigging boats and 5 traps) during 2009–2011. The fishing methods showed opposite catch trends. Jigging captured more squid around new moon periods while trap catch was high around full moon. These trends were not clear in adjacent communities that operate either jigging or traps. We consider both fishing gears utilize the same migrating squid aggregations. It is necessary to distribute fishing efforts in the community to achieve energy optimization and to secure fisheries sustainability.

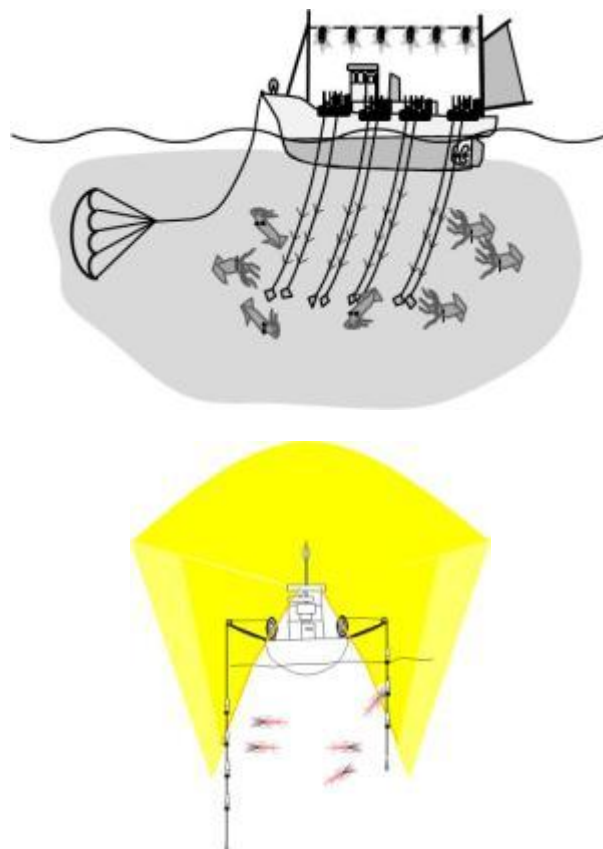


Figure 26. Squid jigging with lights in Japan.

Discussion

Fishing is important for the income and employment in the Nagasaki area. Lamps used for lighting were metal halide lamps at maximum 160 kW per boat, consuming 600–1000 litres of fuel per night. Squid migrate along the Northern Japanese coast. Fuel is a larger proportion of costs in squid jigging, labour in fish trap operations. Pros and cons of the two methods were presented, and the factors affecting the catch. Future activities will feature hydraulic hauling, use of LEDs, optical optimization, prediction of fishing grounds.

The life cycle of the squid species is one year. In the US, squid often live less than one year. It is difficult to say whether there is a danger for recruitment overfishing. Blue colour light is used in the LEDs, because this wavelength is in the peak sensitivity of squid. Trap catches may affect results in jigging. This might be attributable to changes in temperature. A subsidy exists of some 15% to cover expenses for the new lamps from the government. The two fisheries (jiggers and traps) may result in conflict with each other. Licences are given for specific waters, not for the method only. The spatial allocation of gears could be a problem here.

14.2 Energy efficiency analysis (Emilio Notti)

At least since we learned to admit that crude oil reserves are limited, improving energy efficiency has been regarded important. Recently the climate effects of exhaust gases from combustion processes have been increasingly emphasized. This is underlining the importance of improving the energy efficiency in all sectors which are currently depending on the use of combustion engines, among which we find modern fisheries. Actual fishing fleet, in most cases, is not efficient because of outdated technology. Nevertheless there is no question fuel consumption in fisheries can be reduced and should be a directive to do so from the fisheries regulators.

There are new technologies and products available that can reduce fuel consumption and lower exhaust emissions. A suite of measuring devices is used, e.g. fuel meters, (strain gauge) torque meters, rpm counters, gear monitoring systems and load cells for gear drag, etc. A data acquisition system is used to synchronize data from various instruments and make calculations of energy performance parameters. Pelagic trawlers and bottom trawlers are studied. Main characteristics of vessels were shown. Total energy over installed power times speed is used as energy consumption indicator for each mode of operation. Also a fuel consumption indicator is used. Bottom trawlers are similar, but pelagic trawlers show diverging characteristics. Indicators by operation mode were explained as a function of speed. The sailing mode differs from the trawling phase. The vessels were ranked with OTB1 on top. Trawling is the most energy consumptive mode and should be addressed first. The propeller pitch can be optimized for pelagic trawlers. Other cases show improvements by changes in the rigging of the net. All the fishers reduced the steaming speed after the energy audit. The use of ducted propellers is advocated, as these are not commonly used in Italy. The work is to be continued, and trials with a ducted propeller will be done. Finally project ICEEF was mentioned, information collection in energy efficiency in fisheries.

New fishing vessels have a great efficiency level, referred to the actual state-of-the-art. Over the years the energy efficiency of the ship goes down due to obsolescence, while that of the state-of-the-art rises. Maintaining an adequate level of energy efficiency requires a continuous monitoring of the vessel's energy profile through a methodological measurement approach. Any causes of energy inefficiency can be identified, being able to act on them promptly and effectively.

An energy audit tool is therefore essential to maintaining high energy efficiency of the vessel. With an energy audit it is possible to evaluate the energy performance of fishing vessels under different operating conditions. Once energy consumption has been related to each operating condition and speed, fishers can modify fishing operations to minimize fuel consumption through an energy audit which allows an extensive energy profile of the fishing vessel monitored to be obtained. The energy profile is defined through Energy Performance Indicators, so that comparisons between different vessels are possible.

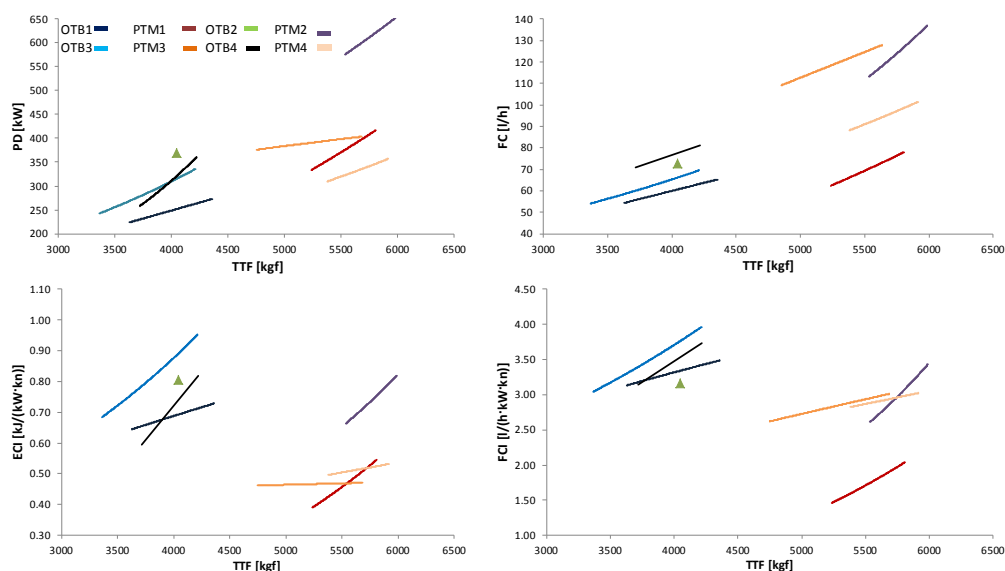
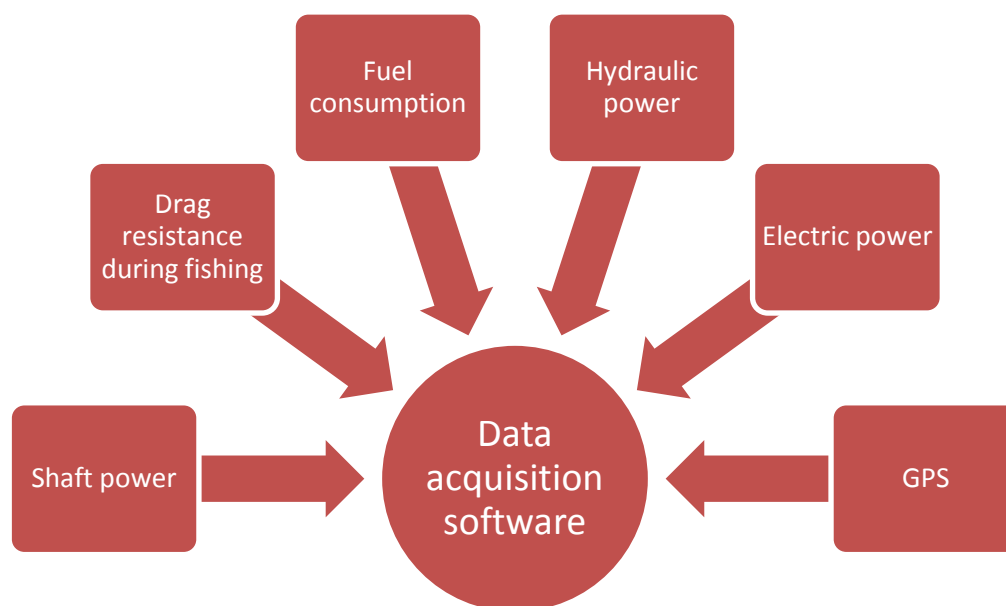


Figure 27. PD power delivered; FC fuel consumption; TTF total towing force; ECI energy consumption index; FCI fuel consumption index; OTB bottom otter trawler; PTM midwater pair-trawler.

Discussion

The use of ducted propellers depends on the costs of a nozzle; payback time is important. This was calculated using 15% fuel savings with the same thrust, pay-back time

can be about 3 years. Investment can be as high as 300000–400000 € in Italy for a nozzle. There is interest also in the USA. There are often secondary savings *e.g.* when reducing towing speed, one can save in engine maintenance and wear and tear of gear components (warps, netting). There may also be changes in fishing time, so it is the balance between earnings and costs that are important. With a nozzle lower power can be used for the same thrust.

14.3 A Low-Cost, Underwater Self-Closing Codend to Limit Unwanted Catch (Mike Pol for Dave Chosid)

A self-closing codend was designed to limit the amount of fish that can be caught in a trawl net. Output controls and strict catch limits (especially for “choke species”) have made catching too many fish a risk to prematurely ending a vessel’s and/or sector’s fishing season. Acoustic catch sensors, which alert the vessel when the codend fills, are a costly solution that does not solve the problem of large catches that fill the codend quickly. Conceived by Capt. Murphy, our innovative codend provides a cheap alternative that quickly clinches tight after catching a preset, adjustable volume of fish; additional fish that enter the net escape safely and easily through the open portion ahead of the closed codend. A parachute also simultaneously releases, creating drag and signalling to the vessel that the codend has tripped. Underwater video of the design was collected on-board a small groundfish trawler, the FRV “Bantry Bay”, in Massachusetts Bay, June-July 2011. Results indicate that the codend successfully and repeatedly triggered and fish were unable to enter the codend once it cinched off. The parachute also deployed as expected but was undersized to provide adequate drag to alert the vessel. We plan to verify the codend’s operation and further refine the design with flume tank testing and expanded field testing to other vessels, with additional collaboration as more fishing experience is brought into the idea.

Dumping the catch is not a good solution, can be dangerous, and is time consuming. The upper and lower (fore and aft) codend were laced together with a zipper line using rings and a simple door bolt. A trigger line reacts on expansion of the bag due to filling. The parachute opens triggered by the line and tightens the codend. This is a cheap solution costing \$750 for new equipment.

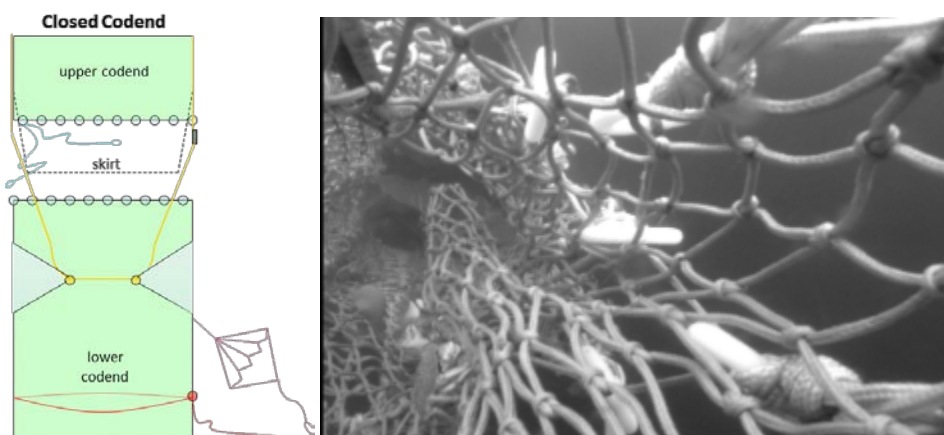


Figure 28. Diagram and underwater image of self-closing codend.

Discussion

Parachute dimensions still need to be optimized. Towing durations are short. Release happens during towing, not during haul-back, but this is not 100% certain. Twisting did not occur. Device gives more peace of mind. Fishers want to be able to live in the existing regulation system, and want it to work. The spurdog stock has recently exploded in these waters, and the management system changes to sector allocations and self-auditing.

14.4 Development of catch control devices in trawl fisheries (Manu Sistiaga for Eduardo Grimaldo)

Experimental fishing with midwater trawls in the Barents Sea has shown single catches that exceeded 50 tons of fish in just a few minutes' towing. High density of pelagic fish means that large quantities of fish enter the trawl in just few minutes, and this is difficult to control even with electronic monitoring sensors attached to the trawl. Big catches can be associated with poor quality of the catch, but also with health and safety related problems. The objective of these experiments was to develop prototypes of catch control devices that could help control the size of the catch and that gently release the excess of fish at the same fishing depth.

The working principle of the new device is the codend closes and is partially detached from the rest of the trawl when it has been filled with a certain amount of fish. The codend drops backwards and remains attached with two ropes to the rest of the trawl. In this way the fish that is still inside the trawl have the chance to escape unharmed.

Full-scale experiments using two prototypes with different release mechanisms were performed in May 2011. Controlled tests of both prototypes were conducted in commercial fishing grounds and using standard equipment. Underwater observations were performed to monitor the release mechanisms, and the reaction of fish to them.

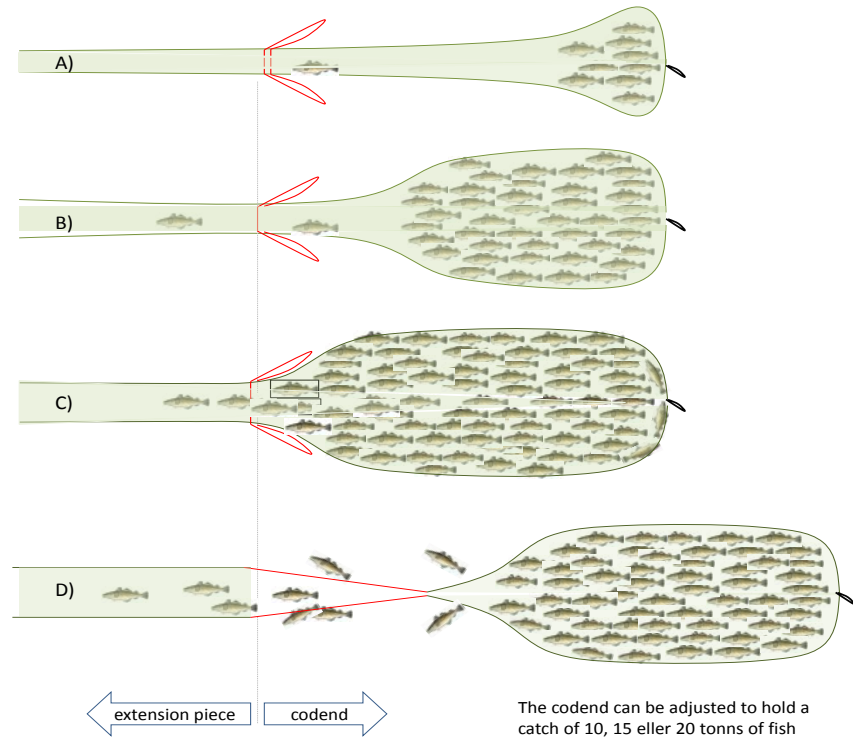


Figure 29. Working principle of codend detachment.

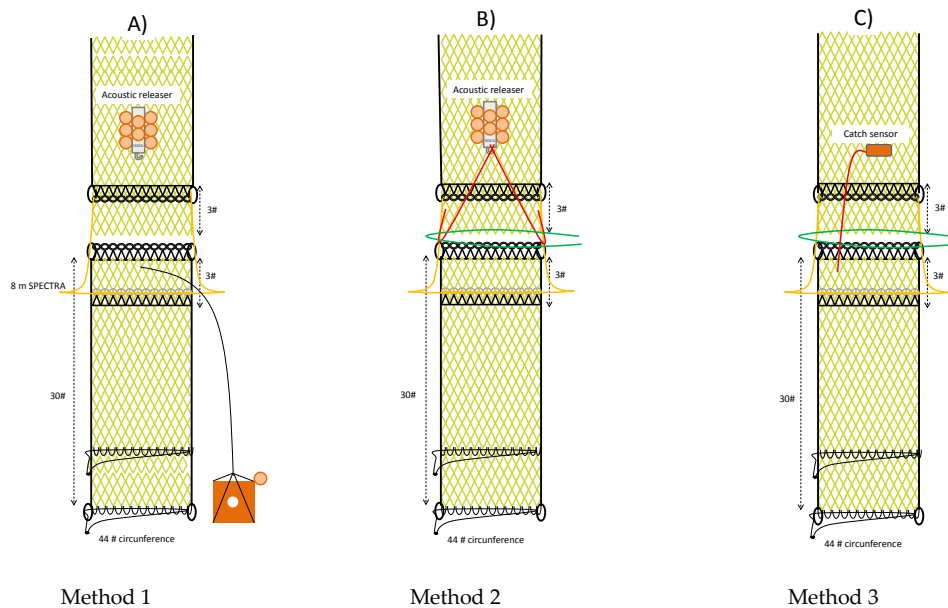


Figure 30. Various techniques developed and tested.

Method 1: Codend will be detached from the extension piece using an acoustic releaser, two rows of rings and a fitting of rope.

Method 2: Acoustic releaser, weak link breaking line (1.8 mm line) and supporting rope (no parachute).

Method 3: Weak link and catch sensor technique. This is the best option.

Flume tank observations and videos were shown.

Discussion

It was observed that this could be addressed in a new Study Group. It was questioned how sensitive the results are to towing speed and species. Trials are needed to determine the thickness of twine to be used for the breaking line.

14.5 A Decade of Research on Shrimp Trawl Design to Reduce Fish Bycatch and Small Shrimps (Pingguo He)

The Nordmøre Grid may be one of the most successful fishing gear devices for reducing fish bycatch in trawls targeting northern shrimp *Pandalus borealis*. However, the Nordmøre Grid cannot reduce small finfish and small shrimps that can pass through the 25 mm spacing currently mandated in the northeastern US. During the last decade, the author and his colleagues conducted several gear-related research projects to further reduce finfish bycatch and small shrimps. The new Rope Grid reduced finfish bycatch by 36–50% without loss of targeted shrimps. The topless shrimp trawl with a cutback headline reduced Atlantic herring bycatch by 87% with a modest increase in the shrimp catch (14%). Simply replacing regular steel bridles with floating synthetic bridles reduced flounder bycatch by about 20%. The new size-sorting grid installed in front of the Nordmøre grid reduced small shrimps below 22 mm carapace length without loss of large shrimps 23 mm and larger. However, the installation of water-borne kites to expand codend meshes did not reduce small shrimp or finfish bycatch. The presentation reviewed and summarized these projects and provided fishing technologists, fishery managers and fishing industry the state of art in gear design and modification available for the Gulf of Maine shrimp trawl fishery. Comments were made on possible applications of these designs in other shrimp and prawn fisheries around the world.



Figure 31. Rope Grid.

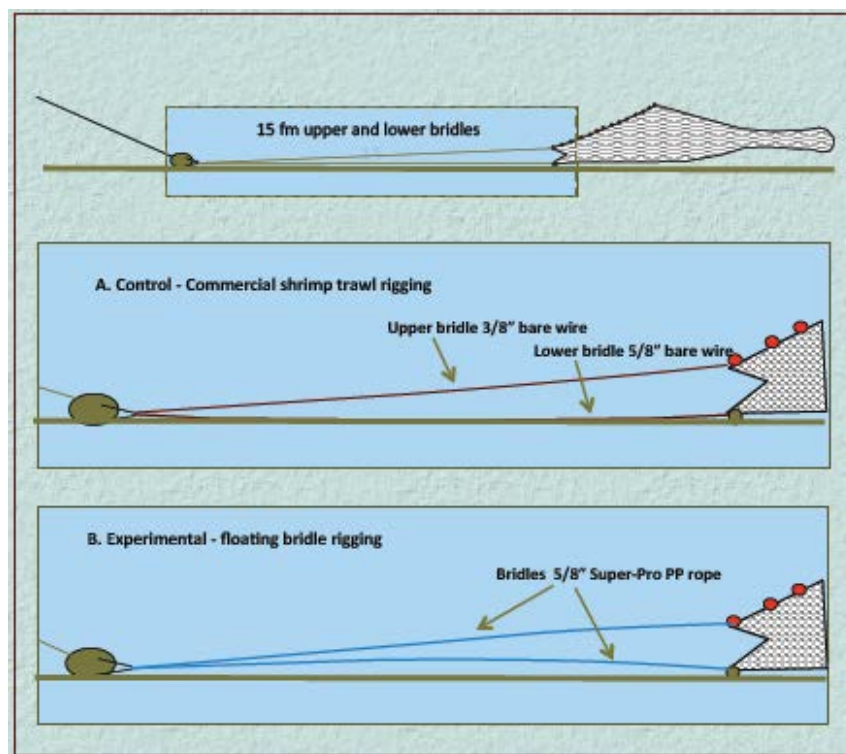


Figure 32. Floating bridles.

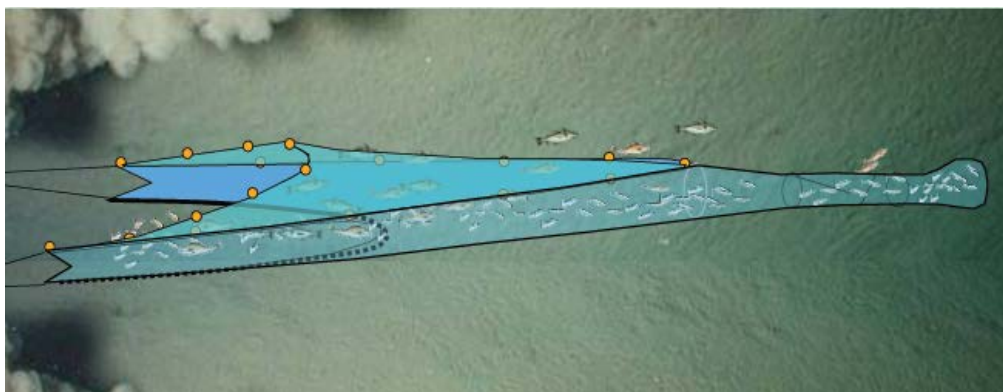


Figure 33. Topless shrimp trawl.

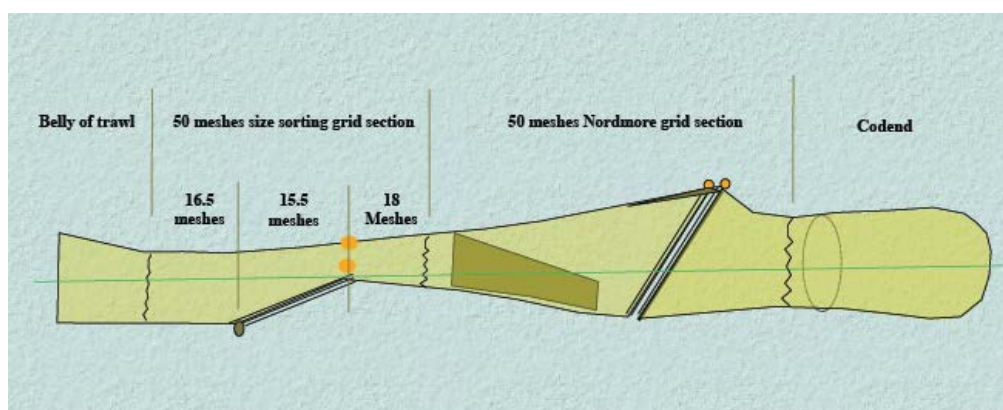


Figure 34. Combination grid system – Size grid and Nordmøre grid.

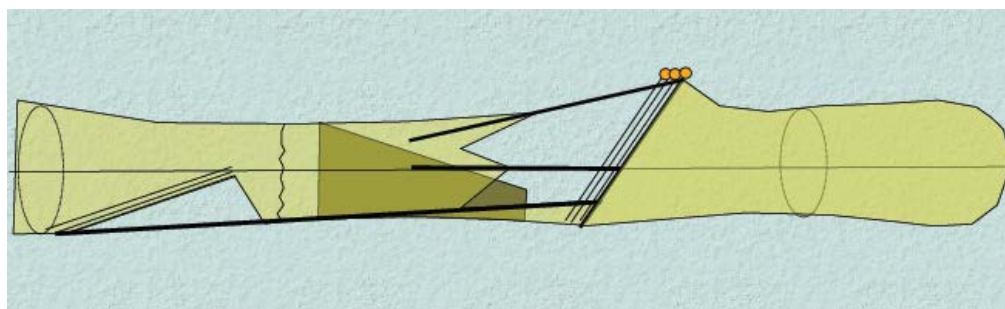


Figure 35. Combination grid system – Size grid and rope grid.

The work on the development of selective shrimp trawls in the Gulf of Maine was done since 2001. The goal is bycatch reduction (also small shrimps), and bottom impact reduction. Shrimps are not herded by bridles. But bridles may herd 2/3 of the fish in.

The Nordmøre type of grid was studied since 1992. The netting around the grid was removed, and it was called 'Rope Grid'. The shrimp catch was not really affected, but the bycatch of silver hake (48%) and red hake could be reduced substantially, also there was less American plaice (40%) in the catch, and witch flounder, especially the larger fish. The results were published in Fisheries Research.

The shrimp size sorting grid was developed to save smaller individuals having a low price. Various designs were tried. Small shrimps (*Pandalus borealis*) can be released. Grid with bar spacing of 9 vs. 11 mm were tested, but with minor difference. The larger spacing was better for larger shrimp. A model was made to predict the size of shrimp, and equivalent weight released as a function of grid bar spacing. An article on effect of grid spacing was published in Fisheries Research by He and Balzano, 2012.

14.5.1.1 References

- He, P., Balzano, V. 2007. Reducing the catch of small shrimps in the Gulf of Maine pink shrimp fishery with a size-sorting grid device. *ICES Journal of Marine Science*, 64, p. 1551–1557.
- He, P., Goethel, D., Smith, T. 2007. Design and test of a topless shrimp trawl to reduce pelagic fish bycatch in the Gulf of Maine pink shrimp fishery. *Journal of Northwest Atlantic Fishery Science*, 38, p. 13–21.
- He, P., Schick, D., Balzano, V., Wells, P. 2008. Use of Kites in Shrimp Codend to Reduce Small Shrimps and Bycatch Species. Northeast Consortium. University of New Hampshire, Durham, NH, Report UNH-FISH-REP-2008-044, pp. 16.
- He, P., Balzano, V. 2011. Rope Grid: A new grid design to further reduce finfish bycatch in the Gulf of Maine pink shrimp fishery. *Fisheries Research*, 111, p. 100–107.
- He, P., Balzano, V., 2012. The effect of grid spacing on size selectivity of shrimps in a pink shrimp trawl with a dual-grid size-sorting system. *Fisheries Research*, 121–122, p. 81–87.

Discussion

Level of uptake is in a number of boats and the incentive is to get rid of small shrimps, as there is no market for them. There are also bycatch limits that give motivation. Shrimp trawling is a big business in many waters, often fish species are targeted, so it is not always a clean fishery. In tropical waters there are many different species and it is difficult to release only the unwanted ones.

14.6 The utility of square mesh codends in UK OTB (Tom Catchpole)

Cefas has investigated the selective properties of square mesh codends on two English otter trawlers. A growing number of skippers of these vessels are developing and using codends constructed from square mesh codends. Meshes orientated into a square shape remain open more consistently than conventional diamond orientated meshes facilitating the escape of small unwanted fish and so reducing discards.

This report presents the results of two experiments designed to demonstrate the difference between square mesh and diamond mesh codends in a commercial setting.

The main findings of this study are:

- There is recognition from the fishing industry that discard rates can be high in some trawl fisheries and skippers have been proactive in developing trawls that catch less unwanted fish.
- Square mesh codends provide a modification to a trawl that can be fitted and operated easily.
- Changing the orientation of meshes from diamond to square in an 80mm codend reduced discards by 25–51%.
- Square mesh codends significantly reduced the capture of small round fish (cod, haddock and whiting).
- Cod discards were reduced by 51% and 78% when using square mesh codends on 80mm and 100mm respectively.
- Several square mesh codend designs were used with no loss of marketable fish.
- Square mesh codends were not effective at reducing the discards of small flatfish.
- Other benefits of using square mesh codends include: improved fuel efficiency, improve fish quality and increased survival of discarded fish.
- Square mesh codends are an easy-to-use modification that can effectively reduce the capture of small roundfish.
- There is currently no EC or domestic legislation that refers directly to the use of square mesh codends on trawls and a legislative model is needed to enable the continued use and development of this tool.

It should be noted that this project was initiated by interest from skippers fishing in the North Sea. The twin-rig catch comparison method was used. Three configurations were studied. A join of 1 diamond to 1 bar of square was used. The Holst and Revill 2009 catch comparison method was used. Plots were shown for WHG, PLE, LEM, DAB, COD, and GUG. Strong length effect found for WHG, LEM, COD and GUG, not for PLE and DAB. Square mesh even caught more LEM, and DAB. Results were presented in a table for 100 and 80 mm codends to the industry, indicating at what length fish are getting lost. General find: a decrease in round fish but increase in flatfish. Discards can be reduced by 105% with 80mm, and 14% with 100mm. Square mesh can be used to target flatfish while avoiding round fish.

The legal status of square mesh codends was studied, no EU legislation exists, only for square mesh panels. Circumference count of meshes is questionable, one can double the number actually. Technical Conservation Measures (TCMs) have to be developed in cooperation with managers and policy-makers, a selectivity group is

put together in the UK for this purpose. Theme C at the ICES ASC 2012 in Bergen, Norway will address this issue.

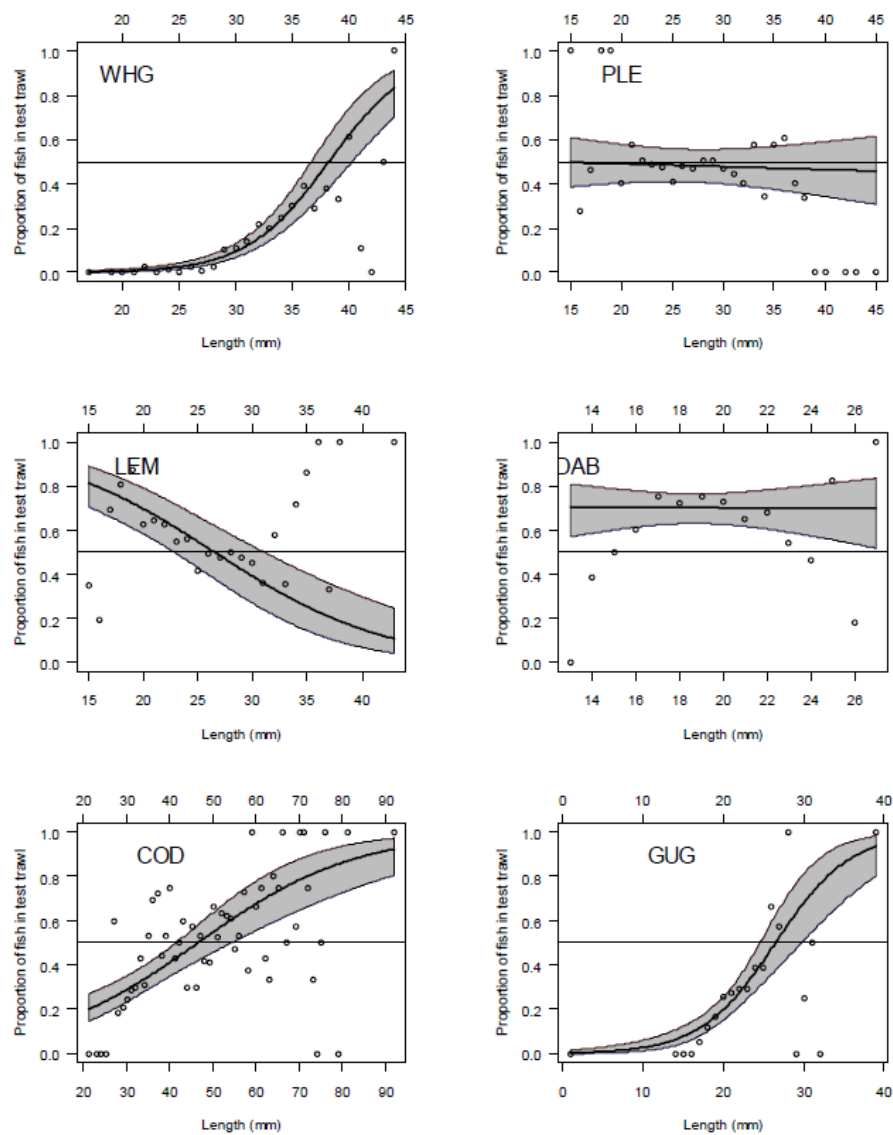


Figure 36. Result for 100 mm codends.

Table 6. Data presented to the industry.

Species	Composite 100mm vs Diamond 100mm	Square mesh 100mm vs Diamond 100mm	Square mesh 80mm vs Diamond 80mm
COD	fewer fish below 45cm	fewer fish below 53cm	fewer fish below 41cm
DAB	more fish at all lengths	fewer fish below 16cm	more fish at all lengths
HAD	-	fewer fish below 38cm	-
LEM	more fish below 28cm	more fish below 32cm	more fish below 23cm
PLE	more fish below 27cm	more fish below 26cm	no difference
WHG	fewer fish at all lengths	fewer fish at all lengths	fewer fish below 37cm

Discussion

The WHG results were discussed. Larger fish appear less, and this may affect the direction of the mean line. Same seems to be the case for LEM. Curves are not a complete match for the data. Model is restricted to a number of curves, so one must be careful with conclusions. One to one join was used, but other ratios were considered. Results seem to match Fonteyne and M'Rabet, 1992 that square mesh is less effective for flatfish, which can be expected from their morphology. The selectivity group attracts interest. Discards are more important in the 80mm codend and therefore more effectively reduced.

14.7 Quantifying fish escape behavior through large mesh panels in trawls based on catch comparison data: model development and a case study from Skagerrak (Ludvig Krag, Bent Hermann, & Junita D. Karlsen)

Based on catch comparison data, it is demonstrated how detailed and quantitative information about species-specific and size dependent escape behaviour in relation to a large mesh panel can be extracted. A new analytical model is developed, applied, and compared to the traditional modelling approach for such data. As a case study, we used data collected with a twin trawl setup. The only difference between the two 120 mm trawls was that a 12 meter long section in the upper panel was replaced with 800 mm diamond meshes (LMTP) in one of them. Based on this very large mesh size, we assumed that all individuals that contacted the panel also escaped through it. The new analytical method was applied to quantify escape behaviour for cod, haddock, saithe and *Nephrops* of different sizes. There was a need to include the full gear selectivity in the trawl, and we show how this selectivity can bias the interpretation of the length based escapement behaviour over the large mesh panel. Our length based behavioural description is in good agreement with direct observations of the same species in the trawl cavity reported in literature.

Fish behaviour understanding is essential. Observations are often difficult using optical devices such as cameras. The alternative is to use catch data to reconstruct behaviour. Every fish in every haul counts. Bootstrapping can be used. An experimental catch comparison index was calculated. Length frequency distributions and catch comparison rates are not suitable to infer behavioural patterns. A full gear selectivity model was developed in which data of low lengths was deleted and double bootstrapping is used. Catching is a sequential process. Panel contact was assumed leading to escape. Flounder shows strong length dependent escape behaviour. Curves were presented for COD, HAD, LEM, POL, and WTH. Comments made on knife-

edge curves found for cod using stochastic simulation, apparently caused by data weakness. LMTP affects fish but not Nephrops.

Discussion

Data were collected during day, so no results for day-night differences, but this can be done. The depth ranged from 200–300 m, trawls are approximately 2 m high. Cameras could not be used due to poor visibility. A publication will be written.

14.8 Escapement efficiency through a square mesh panel (Bent Herrmann, Harald Wienbeck, Junita D. Karlsen, Erdmann Dahm, Waldemar Moderhak & Daniel Stepputtis)

Square mesh panels are often inserted into diamond mesh codends or trawl sections prior to the codend with the aim of improving the escape efficiency of undersized round fish. The BACOMA codend is such a construction which has been proved to be efficient in selecting out juvenile cod in the Baltic Sea trawl fishery. The square mesh panel continues to the aft end of the codend. It overlaps with the catch accumulation where the fish, except from entering the catch, have no other option than to try to escape. The BACOMA codend consists of an upper panel of 120 mm ultra-cross, and a lower panel of 105 mm diamond mesh. The catch goes to the very end of the codend. Questions raised were: What makes BACOMA so efficient? Is it this last section, or the panel position? Would it be possible to stimulate an escape response in cod through a less optimal positioned square mesh panel and thereby achieve a size selectivity comparable with that of the BACOMA codend?

Using different variants of BACOMA like codends during a sea trial the square mesh panel escapement efficiency for Baltic cod and some bycatch species were investigated. In particular the dependency was investigated of the efficiency of letting the panel extend into (overlap with) the part of the codend where catch accumulates. Further for a non-optimal panel location the effect on applying an escapement stimulation device was tested.



Figure 37 FRV "Solea."

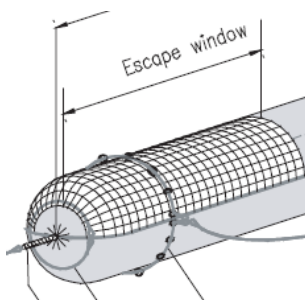


Figure 38. Escape window used.



Figure 39. Work on board.

A research cruise was made in March 2012 on RV "Solea" using four different codend designs:

- 1) BACOMA
- 2) Reduced panel area (47%) overlapping with the part of the codend where catch accumulation takes place

- 3) Reduced panel area (47%) no overlap with catch accumulation part
- 4) As 3, but with stimulating ropes attached to lower panel.

A total of 30 hauls were done in an alternate haul experiment, during which 17262 cod above 33 cm were measured with no subsampling at all. The SELNET tool was used for analysis with double bootstrapping to account for both within and between haul variation. Cod smaller than MLS were released by 64% in the standard BACOMA codend. A reduced panel gave a slight decrease in selectivity (ns), but a more dramatic decrease (s) was found when taking out the aft most part of the panel. Then stimulation ropes were added in the lower (diamond mesh) part of the codend to chase cod up, but without any positive effect. Random fixed analysis was done using models for L50 and SR. These models were:

$$L50 = \text{INTERCEPT_L50} + \text{REDUCED_L50} + \text{OVERLAP_L50} + \text{STIMULI_L50} + \text{CODEND_CATCH_L50} + \text{SEA_STATE_L50}, \text{ and}$$

$$SR = \text{INTERCEPT_SR} + \text{REDUCED_SR} + \text{OVERLAP_SR} + \text{STIMULI_SR} + \text{CODEND_CATCH_SR} + \text{SEA_STATE_SR}$$

A total of 4096 models were tested using AIC, and the best model chosen, resulting in the following best models:

$$L50 = \text{INTERCEPT_L50} + \text{OVERLAP_L50} + \text{SEA_STATE_L50}, \text{ and}$$

$$SR = \text{INTERCEPT_SR} + \text{SEA_STATE_SR}.$$

This means in other words that intercept, overlap, and sea state were found as significant explanatory variables. No overlap reduced L50 by 5.8 cm, while bad weather tends to affect it negatively. The panel area can be reduced by 47% without drastic effects on selectivity, and stimulation ropes do not work, but it is not clear why not. Direct observation showed the ropes to lay more or less flat on the netting of the lower codend. The trials will be continued. It was suggested for WGFTFB to look further into the efficiency of SMPs and ways of stimulating escape behaviour.

Finally a word of thanks was addressed to Harald Wienbeck of VTI Germany, who will retire next year, for giving the opportunity and allowing research vessel time.

Discussion

Cod often do not seem to behave stressed inside nets. This non-escaping behaviour of cod in codends has also been observed by other workers. Observation showed that escape of cod only often happens at the very end. Skippers did not like the panel being placed very aft at the beginning, but the BACOMA codend was designed as it is because of this typical behaviour of cod. A shorter panel might indeed be a good idea. Parabolic stimulation ropes might work better than ropes streaming lengthwise with the current. More fish were caught with the stimulators perhaps due to mesh blockage. The idea for a topic group on this subject was welcomed with the advice to emphasize effects on biodiversity and indicating the number of scientists that may attend.

14.9 Slipping from purse-seines – Simply a source of unaccounted mortality or a potentially responsible way of controlling the catches (Maria Tenningen)

Catch regulation by slipping whole or parts of a catch has traditionally been used in the purse-seine fisheries for pelagic species if the catches are too large, or when there

is a large price difference among fish sizes or qualities. But is this practice acceptable or does it contribute to high levels of unaccounted mortality in the fisheries?

To try to answer this question the effect of crowding on herring (*Clupea harengus*) and mackerel (*Scomber scombrus*) were examined in large-scale field experiments conducted in the North Sea between 2006 and 2012. The results provide information on mortality rates at different densities and indicate that slipping in a late phase of hauling may lead to unacceptably high mortality and should thereby not be allowed. The experiments, however, also show that at least herring tolerate crowding at relatively high densities well (up to 100 kg/m³), indicating that slipping in an earlier phase should be acceptable. One of the current challenges is thereby to determine how long into the hauling process slipping can be accepted. It is very challenging to monitor the purse-seine and the catch inside the net due to the size of the net and the continuously changing form and dimensions. A new project, where the fishery sonar and acoustic transponders are used to estimate the volume and shape of the purse-seine through the haul, may provide information on the space available for the fish inside the net and on the point during the hauling process when the fish density is getting critically high.

Purse seining did not get much attention recently. Catches can be as high as 1000 tons per haul. The total herring catches are 500000 tons, and mackerel catches 180000 tons in the Northeast Atlantic. There is presumably a high unaccounted mortality in mackerel fisheries; the real catches might be twice as high. The mackerel were crowded in the experiment for 10–15 min. Controls show lower mortality, treated fish as high as 100%. With herring, mortality increases with crowding density to about 60% at 400–500 kg/m³. Fish slipped late in the process may die. A total ban on slipping is not realistic, but the need for a regulation exists. The way forward is to try to reduce the need for slipping. The current rule stating when 7/8 of net is retrieved then no more slipping should be done is problematic for the fishers. More information was needed. The trials were done to identify the critical fish density using a omnidirectional fishing sonar and accurate acoustic underwater positioning system (HiPAP) on MFV "Libas". A 3D reconstruction of the net was made and the experiments will be continued in autumn 2012. Slipping can be used to control the catches, but needs to be regulated. Critical densities need to be identified. Fishers should be able to get information on the catch in an earlier phase during a haul.

Discussion

WGFTFB should have a wider scope than trawling and this topic is welcomed. Survival experiments at sea are difficult to conduct. Apart from density duration of crowding is also an important variable. Slipping may happen in many fisheries and this is an important issue. Technologies for capturing catch information are getting more important, *e.g.* for monitoring fisheries visually using CCTV for management schemes based on total catch. The contact and communication with fishers in this study was very good. We need better slipping mortality estimates indeed.

14.10 Predicting and mitigating the benthic impact of towed gears – a case study with a clump weight (F.G. O'Neill, A. Ivanovic, L. Robinson and R. J. Fryer)

In this paper we demonstrate the possibility of developing quantitative models at the level of gear components that will allow predictions of post-trawl abundance to be made based on biological traits information. We show how changes in the counts of

species in core samples taken pre and post trawling in the path of the gear components are related to the cross sectional area of the sediment impacted by the trawl component. We also explore biological traits and demonstrate for the trawl door data that being tubiculous, a surface dweller or a burrower is important and for the clump data living range is a significant factor. We further enhance the predictive capabilities of this approach by numerically modelling the physical impact gear components have on the seabed using the Abaqus Finite Element (FE) software package. These models are able to predict the penetration depth into the sediment, the sediment displacement and the drag forces acting on the gear component. We combine the biological traits model and the physical impact model, and show how it can be used in a design sense to assess the impact of alternative clump designs. In particular we examine the consequences of changing the size and/or shape of the clump and demonstrate how relatively simple design changes could lead to substantial reductions of benthic in-faunal disturbance related to towed fishing gears.

The work is in progress, and done over the last two years. Earlier work using the BACI method is useful for general trends, but provides no predictive models. Here quantitative prediction is sought at the gear component scale. The biological traits model is based on the probability of encounter. The working area was the Moray Firth. Tow tracks were identified by divers and markers were set. Core samples were taken from various positions in the trawl tracks. Laser line metrology was used. Biodiversity indices were calculated, and a GLMM on counts was used, including prior estimates. The proportion pre-impact over total (post +pre) was plotted against the number of individuals. At 0.5 there is no difference. In the door path there is a significant difference, the sweep and groundgear cause only small differences, while the clump produces a significant difference. Laser line photos were presented and compared to technical measurements. Penetration depth was determined and proportion of impacted area. More area impacted resulted in more removals.

Predictive models of physical impact were further developed, based on the balance of forces. Stress-strain relationships for several types of sediment were varied. Large sediment displacements are happening in the trawl track. The impact of discs from the groundgear was shown in diagrams. In softer sediment the tracks are more defined. An experimental set up using a tow tank was shown. The drags and forces can be measured. Photos and videos of full-scale trials were presented. A good correlation was found between the simulated and observed measurements, thus the predictions are accurate. In the design study the clump shape, weight, and diameter were varied. The penetration of the clump can be reduced with a larger diameter, or using an aerofoil cross sectional shape using the same weight. The drag can be reduced by 60% with the aerofoil shape and also penetration and removal of in-fauna. These models therefore can be used in gear design. Measurements were done at sea on physical scale models using a rack to hold the devices. At higher towing speed the clump may come out of the sediment (penetration depth reduced from 110 at 1.0 knots to 40 mm at 2.0 knots), and fewer animals are being affected. Fishing faster may thus be better to reduce bottom impact. The medium-longer term impact is still to be investigated.

Table 7. Proportion removed, penetration depth and area impacted by gear component.

gear component	proportion removed	penetration depth (mm)	area impacted (m2)
control	0.03	0	0
door	0.63	72	0.48
sweep	0.15	5	0.03
groundgear	0.18	100	0.15
clump	0.59	110	0.73

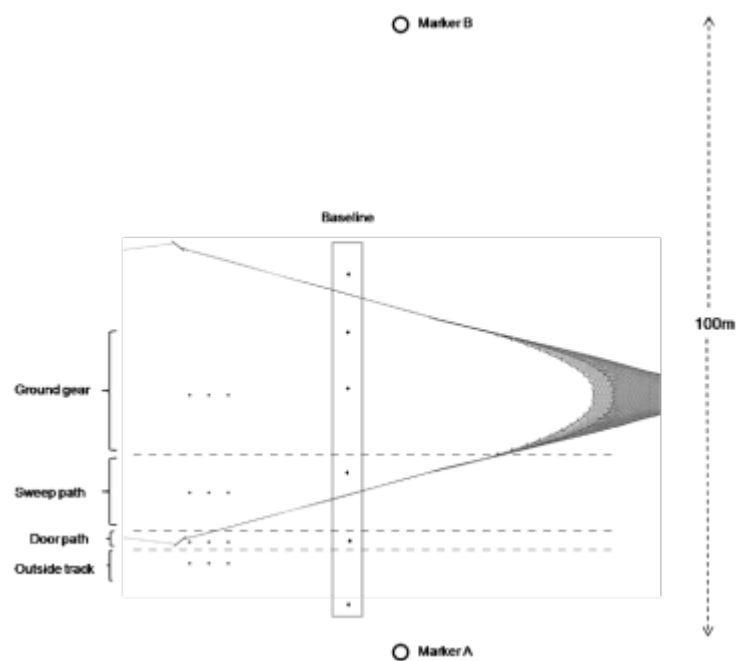


Figure 40. Regions sampled from the trawl track.



Figure 41. Clump shapes tested.

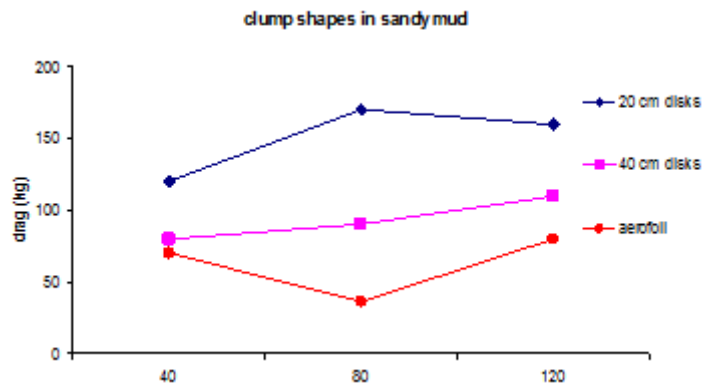


Figure 42. Differences in drag of clump shapes.

Discussion

A good link between technology and biology was developed in this study. Fuel consumption should be taken into account as well to determine impact. Absence and removal were assumed to be linked with mortality.

14.11 Catch comparison of pulse trawl vessels and a tickler chain beam trawler (Bob van Marlen)

Catch comparison trials were carried out on three vessels, MFV TX36 (fishing with HFK pulse wings), MFV TX68 (fishing with DELMECO pulse trawls), and MFV GO4 (fishing with conventional tickler chain beam trawls) fishing in the same area side-by-side in May 2011. The pulse wing is a trawl in which the 'SumWing' concept is integrated with pulse stimulation, and was used on-board TX36. A total of 28 pulse modules spaced 41.5 cm apart are placed inside the wing and connected with parallel electrodes. The electrode array extends over ~6 m. The nets used on TX36 differ from the conventional model. The aft part was made of two identical parts next to each other. The DELMECO pulse trawl has 25 electrodes across its width spaced 42.5 cm apart, and was used on-board TX68. The nets used on TX68 were derived from the conventional beam trawl design.

Conclusions of the work were:

- Lower fuel consumption (40–50%)
- Higher net earnings (150%)
- Fewer landings (60–80%)
- Fewer discards (30–40%)
- Spinal fracture in cod ca. 10%
- No spinal fracture in whiting

Possible future work:

- Investigate ways to decrease effects on cod
 - Higher pulse frequencies (> 180 Hz)
 - Affect cod behaviour in trawl
- Measure field strength in situ on-board TX-19
- Monitor future developments in pulse characteristics

- Extend catch and bycatch data by further monitoring of pulse trawling, and more catch comparisons side-by-side
- Further debate in SGELECTRA
- Further studies on ICES-questions when these are asked for
- Compare direct mortality of benthic invertebrates of recent 12 m pulse trawls with conventional beam trawls
- Current FP7 proposal BENTHIS (Trawling impact)
- Evaluate effect of introducing pulse trawls in North Sea fleets on major target species and non-target (benthic) species
 - Current FP7 proposal BENTHIS (Trawling impact)
 - Extend and improve models linking physical properties to biological effects

Table 8. Comparison of performance between the three vessels.

Gear	Fuel (%)	Total catch (%/h – %/hect)	Landings (%/u – %/hect)	Discards (%/u – %/hect) fish + ben-thos	Nett Earn-ings/h (%)
CONV	100	100	100	100	100
PULS	43	37 – 48	62 – 81	33 – 43	156

Table 9. Spinal fractures found in cod.

Vessel	N in total catch	No of fracture	%
CONV	48	0	0
PULSE HFK	27	2	7.4
PULSE DELMECO	18	2	11.1

Table 10. Summary of Catches Per Unit of Effort (cpues) based on auction data.

Gear type	Conv.	Pulse	Pulse/Conv.
Species code	kg/h	kg/h*	%
PLE	34.9	24.9	71.4
SOL	17.6	15.1	85.9
DAB	3.4	3.6	104.6
TUR	3.6	2.9	81.8
BLL	2.00	2.03	101.7
COD	1.8	0.6	30.7
WHG	2.7	0.7	25.1
VAR	24.1	10.7	44.4
landings	90.1	60.5	67.1

Discussion

Constant DC supply might be less damaging on cod than AC according to the literature. This might be looked at, the pulse shape was developed for catching sole and plaice, and AC was chosen to reverse polarity and avoid dissolving electrodes by electrolysis.

14.12 Measuring sediment mobilization by fishing gears using a Multi Beam Echo Sounder (F.G. O'Neill, Dan Parsons, Steve Simmons, J Best, Phil Copland, Eric Armstrong, Mike Breen and Keith Summerbell)

Here we show how we can use the RESON 7125 MBES to quantify the concentrations and densities of sediments that are mobilized into the water column in the wake of towed demersal fishing gears. We examine the sediment plume in the wake of a demersal otter door and a roller clump and compare concentration measurements taken optically by the LISST 100X and acoustically by the RESON 7125 and show that they correspond very well. This will permit the amount of sediment put into the water column in the wake of towed gears to be measured remotely. Hence when these types of measurements are combined with spatially and temporally refined fishing effort data and spatially refined data on seabed sediment type it will permit the assessment, at the fishery level, of the impact of towed demersal fishing gears on a range of environmental and ecological factors such as nutrient release and benthic faunal mortality.

A 3D picture of the plume was also presented behind a door and a clump. Depth and calibration form limitations to the approach and it can be predicted which depth ranges can be addressed.

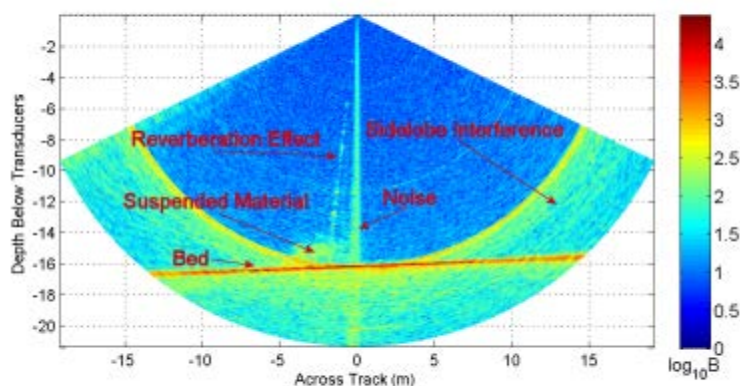


Figure 43. RESON echogram with sediment.

Discussion

The expectation was expressed to see more homogenous distributions. The seabed is not necessarily homogenous in terms of sediments, and these plumes can be quite chaotic.

14.13 Prediction of the vertical forces applied on the seabed by a trawl gear (Francois Theret)

This short presentation considered the different components of a demersal trawl gear.

The presenter is now working for a trawling company. Simulations were done using Ifremer's DynamiT software of a French Scapêche trawl used by large trawlers with emphasis on footropes, cables and otterboards. The forces generated on the seabed by the footrope are the resultant forces in each point of the weight of the footrope in water, forces applied by the netting (hydrodynamic drag and internal tensions), and friction forces of the movement over the seabed and can be calculated along the footrope. Also the force generated by each bobbin. The weight in water of the footrope (composed of rubber and steel) is not easy to determine.

The footrope was made 9m long with 30 bobbins weighing 380 kgf in air, and 98 kgf in water. Each bobbin was 3.3 kg. The netting generates a force of 0.55 kgf on each bobbin at 3.3 knots, the resulting force on each bobbin when fishing was 2.75 kgf. A bridle made of 28 mm steel cable (when fishing: 2.6 kgf/m) with estimated 1 cm contact with the seabed resulted in a force of 26 g/cm², otterboards gave 125 g/cm² (vertical force less than 250 kgf in fishing condition, weight 2000 kgf, area in contact with seabed: 2000 cm²). Bobbins generate less pressure than each foot of a child of 6 months old, doors less than each foot of a man of 75 kgf. Thus the result was that the pressure on the seabed is rather low and comparable in magnitude with the pressure exerted by human feet.

Next steps will be to look at a light footrope and simulation of time needed for recovering ground contact, work on an off-bottom trawl EU-project, and a new (jumper) door or a winch controlled by the signal of a bottom contact sensor.

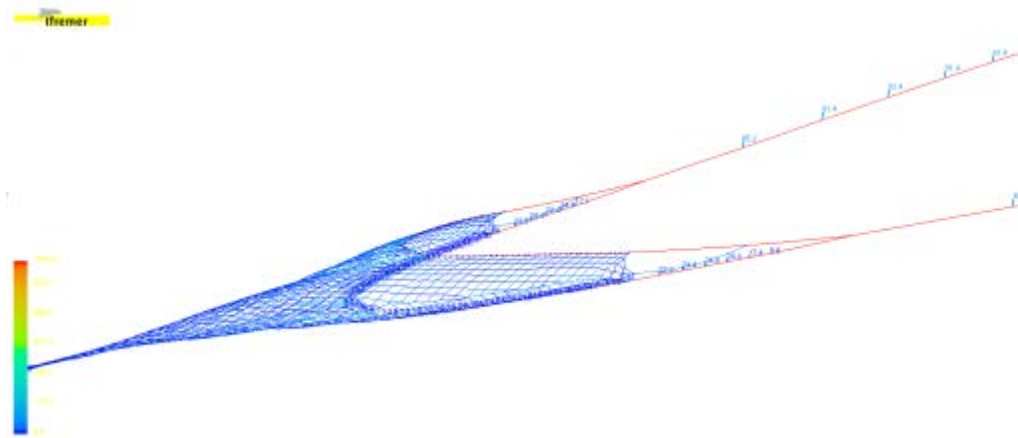


Figure 44. DynamiT trawl simulation.

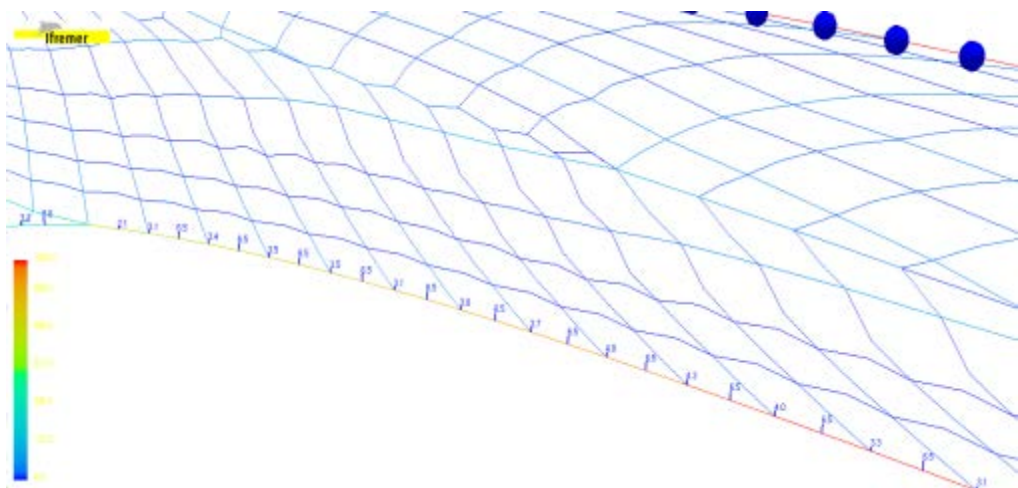


Figure 45. DynamiT trawl simulation detailed, with vertical forces on the footrope.

Discussion

The vertical forces were determined by injection of the vertical force to stabilize each point at the seabed. The system moves free in the water and reaches force equilibrium. The vertical force generated by the door depends on warp length, and was in our example 250 kgf.

14.14 Light and vision (Chris Glass)

General background information was presented to underwater light and vision. Fish eyes come in all shapes and sizes, but the structure is similar. The refractive index in seawater and the cornea is similar. The lens can be changed in shape as humans can do. Light underwater plays of course a major role in vision. It can be measured by radiometry (in Joules, quanta and Watts) and photometry (lumens, lux, nits, footcandles). The Photopic curve is important. Illumination is expressed in lux or metre candles (lumen/m²) or radiant power (W/m²), or $\mu\text{E}/\text{s}\cdot\text{m}^2$ ($E = 6.023 \times 10^{23}$ photons). Radiant energy, flux or power (W), flux density, intensity (W/sr) and irradiance (W/m²) are all radiometric terms. Photometric equivalents are also mentioned with

corresponding units. The visible part of light ranges from 400 nm – 700 nm wavelength. Blue (37.5 m), green (25 m), and red light penetrate in water in this sequence. At 30 m depth mostly blue and green light remains. Light enters the fish eye from all directions, from the surface, but also reflected from the bottom or particles in the water column, thus with multiple path lengths. The light field that fish live in is monochromatic mostly, looking up is light, looking down is dark. The contrast of white, grey or black items differ vertically against the background. Twines and ropes look very different underwater than in daylight, most colour is lost with depth. Twines can be very different in visibility and contrast looking up or down. Contrast decreases as light intensities fall. The Gulf III sampler mouth picture was shown, looking like a gaping mouth. Mirrors can be used to change this and make it undetectable. This principle is also used in nature, e.g. herring have reflecting scales, thus rendering them a lot less visible. We can learn a lot from many animals. Image formation and artificial light will be addressed in more detail in the topic group on light. A video clip illustrated the effect of contrast on visibility.

Discussion

Fish use all senses, not only vision. Many seas have almost no light and very turbid waters. We have to learn about all sensory systems, hearing is also important. Visual thresholds are not known for all species. Mackerel can still see at 10^{-6} lux, whereas humans lose vision at light levels lower than 10^{-3} , a factor three less in magnitude. Fish behaviour studies very frequently reported some 25 years ago, but little of this kind of studies is done at present. Fish can see much better than humans, and this should be kept in mind.

14.15 Synthesis of International Fishing Gear Laboratories Organization (Sonia Mehault)

In 2011, Ifremer organized an internal seminar to question the role and perspectives of its own fishing technology laboratory. In that context, a questionnaire was sent to the WGFTFB members to better understand the trends abroad, and to generate a road map for the future. A total of 19 institutes, most of them public, answered. The status of organizations (private vs. governmental) and funding varied. Most funding is still national and governmental money, followed by EU-funding, and by institute funds. It followed that: 1) there is a trend to merge fishing technology and fisheries biology departments, 2) the mean number of permanent staff is 5, 3) most of the laboratories are multidisciplinary with the main skills being fisheries biology, statistics and mathematics, gear technology, engineering, electronics/acoustics, naval architecture, netmaker, observation techniques, hydrodynamics, GIS, and 5) the main topics studied are respectively: gear selectivity (passive or towed), energy saving, environmental impact, fish behaviour and alternative gears.

Most of the members who contributed to this survey expressed optimistic views for the future of fishing technology because: 1) there still remains a lot of work in this field, 2) there is a growing demand for fishing technology work, 3) the fishing sector is in transition and requires new techniques, 4) gear technologists are needed because they provide a bridge between the scientific community and the fishing sector and 5) fishing gear science is needed to address the problem of technological creep. However, some scientists observe that: 1) there is less and less possibility to conduct fundamental research, 2) new themes are emerging without much more means (e.g. renewable marine energy production), 3) there is inconsistency between increasing demand for gear technology (e.g. FCP), 4) there is a reduction of means to achieve the

work, 5) there are fewer gear technologists employed in laboratories and graduated from universities, 6) there is a tendency to replace them by 'biologists', and finally, the reduction of staff (and money) prevent to work in the way needed.

It appeared from this survey that fishing technology workers need to be more innovative and proactive, cooperate with a wide range of workers in the fishing sector, keep expanding the international network to find solutions, and increase cooperative science by involving the fishing sector to a greater extent.

Discussion

Staff is perhaps declining because of a lack of interest by superiors. The question was raised whether we need to fight against social pressure. There is a need for work on fishing technology, looking at the process of developing new gears, which requires specific expertise and experience, and a number of techniques and facilities not always present in the fishing industry (direct observation, flume tanks, knowledge of hydrodynamics, physics and statistics). There are many current activities to enhance contacts within the fishing technology domain (e.g. by SINTEF, and the European Fishing Technology Platform (EFTP)), and we should define our specific role in relation to these. In the EU fishing technology activities may be declining, but in other parts of the world these are growing. The EU research institutes are confronted with an economic crisis, cuts in budgets are to be expected in the near future, if not already happening, but not only in fishing technology.

This group should be proactive. The new scientific paper 'reconsidering selective fishing' may change the views on selectivity, should we not respond on this? What are other important topics? Sampling? Food quality? Also survey technologies are important, and there are examples of surveys that need a professional technological input to deliver results that can withstand scrutiny (stock assessment gears, plankton samplers). There is still a demand for our work, but has our communication been too poor? Increasing efficiency in fishing gears was deemed a long time ago as suspect and even unwanted and against stock conservation objectives, both within ICES and in the EU. As a consequence we did not get funding for technology development in the EU for a long time. There is also a need for interdisciplinary projects (involving: biology, technology, economy, and social sciences). For seeing selective gears applied clear incentives are necessary, otherwise they will not be used. The fishing industry wants to get more data on fish stocks. A debate runs currently about the future in Norway about the next 20 years with scientists, industry representatives, and instrument makers. The discard ban may generate much new research work, and incentives will be high if a discard ban will be issued.

More emphasis should be placed on public-private partnerships. Questions are: who will pay, and how to organize this? The industry consists of separate businesses and is not uniform. Innovations need to be financially supported by governments.

Fishing Technology almost disappeared as a topic in the strategic plan of ICES. We may have been seen as a somewhat different group within ICES, communication may not have been very good, but there is more appreciation today for our input than at times in the past. There was often a notion expressed within ICES that more efficient fishing gears are not needed and contradictory to conservation purposes.

Too much work may currently be done on a national basis, and a plea for combining efforts is given. Innovations need time and the right preconditions to get adopted. A topic group on the future of fishing technology may be established. Fish behaviour

also needs to be addressed, keep the “B” in. This might be a theme for the ICES ASC of 2013?

15 National Reports

15.1 Review of National Reports (Mike Pol)

Participants were asked prior to and during the meeting to prepare summaries of current and expected research related to the activities of the WG within their country. Twelve nations submitted reports on research activities in 2012, representing more than 28 institutions and reporting on over 168 different research projects. Notably, a report was received from Japan, thanks to the presence of a prominent Japanese researcher.

The full text of the reports is provided below, by country. A general overview of the reports was presented by the Chair at the meeting. A more complete overview was written after the close of the meeting and after the submittal of more reports. A word cloud was presented at the meeting representing the full text of the reports. (Figure 46). The word cloud displays words in font sizes proportional to their frequency within the text – the bigger the word, the more frequently it appeared in the reports. The word counts are also displayed in parentheses.

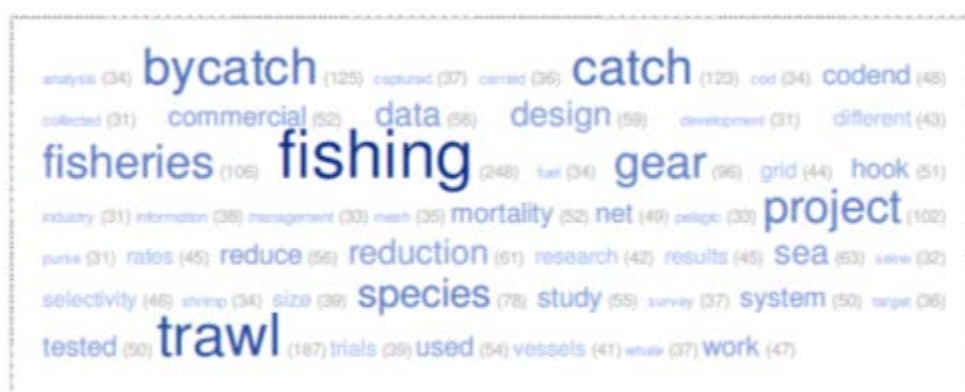


Figure 46. Word cloud of the National Reports.

The contents of the individual National reports are NOT discussed fully by the group, and as such they and this summary **do not necessarily reflect the views of the WGFTFB**.

Nine themes were identified in 2011 to summarize the overall research: energy efficiency and habitat impact; trawls and dredges; non-trawl gears; behaviour; animal welfare, quality, handling and mortality; crustacean fisheries; protected species; technological advances; survey gears; other. Projects in 2012 were sorted into these categories based on the primary focus of the project description, although it is acknowledged that many projects overlap more than one theme. In 2012, these categories continued to capture the range of reported projects well. The most projects were reported in energy efficiency and environmental impact: thirty or so projects were reported by nine countries, with Canada leading with at least eight projects involving reduction of mobile gear impact and fuel consumption. Japan reported four projects reducing fuel consumption via changes in lighting. Innovations in Spain

concentrate on alternative fuels and fuel additives, and engines. It is expected that this theme will continue to be an area of focus.

Some of the 27 reported non-trawl gear projects are motivated by fuel efficiency and reduced bottom contact. Canada, USA and Norway in particular accounted for 20 projects in this theme. Pots were under development for finfish and crustaceans in several countries; weak hook studies were a particular focus in USA. Other study involving gillnets traps, shark bycatch reduction with electromagnetism, ghost gear, and other topics.

As is typical for the group, over 30 projects primarily fitting into the trawls and dredges theme were reported, involving 7 of the reporting countries; these projects included demersal, semi-pelagic, and pelagic gears. A wide range of subjects were under investigation, notably species separation. The development of catch control devices in several countries was noted as an innovative direction, and a topic group on this subject was proposed.

Twenty-one projects were placed in the “other” theme, from nine of the eleven reporting countries. These projects were naturally the most diverse, including translation of Russian and Japanese gillnet papers, artisanal fisheries, identifying historical technological creep, collaboration networks with fishers, integrated fisheries management, and others.

Crustacean fisheries (14 projects from 7 countries), technological advances/upgrades (14 projects, six countries) and protected species (17 projects from 5 countries) continued to be strong themes. This year’s summaries reported fewer projects on survey gears (9 in 4 countries), behaviour (7 in 4 countries), and animal welfare, quality, handling and mortality (9 in 3 countries).

15.2 Canada

15.2.1 Fisheries and Marine Institute of Memorial University of Newfoundland Simulation vs. Flume Tank

Few examples exist in which the accuracy and precision of numerical and physical modelling techniques have been compared to full-scale trawl performance at sea. A project has been initiated to statistically compare 3 datasets (numerical vs. physical vs. full-scale) for the Campelen 1800 survey trawl. We hope to discuss the merits/limitations of each approach and how each can assist the gear development cycle. Contact PhD student Truong Nguyen (Truong.Nguyen@mi.mun.ca).

Energy Efficient Shrimp Trawls

Two parallel projects are underway to investigate methods of reducing fuel consumption during inshore shrimp trawling activities in Newfoundland. We tested the feasibility of shortened bridles, reduced twine diameters, modified footgear, increased mesh size, and improved trawl door design, all as means for reducing hydrodynamic drag and saving fuel. The work was conducted under the controlled conditions of a flume tank using scaled engineering models (1:4, 1:8, 1:40). Full-scale sea trials were conducted in 2011 with additional trials planned for this summer (2012). Contact George Legge (George.Legge@mi.mun.ca) or Harold DeLouche (Harold.DeLouche@mi.mun.ca).

Reducing Seabed Impacts of Bottom Trawls

A five year project has been initiated with an industry partner to develop bottom-trawl technology capable of catching commercial quantities of finfish and shellfish with reduced seabed contact compared to traditional systems, thereby reducing significant environmental impact on the seabed. The objectives of the project are to conduct computer simulation of innovative fishing systems; evaluate physical models using the flume tank; and construct and evaluate full-scale prototypes. Contact Paul Winger (Paul.Winger@mi.mun.ca).

Underwater Camera Development

The university's self-contained underwater camera systems were upgraded to high definition (full HD, 1080p) with solid-state recording on DVR. Under laboratory conditions, we compared the performance of the new system to four similar camera systems used during the last decade. Our laboratory study results revealed that HD video could offer significantly improved image quality by up to 20%. We also tested its performance at-sea attached to an offshore groundfish trawl and found surprisingly good image quality, so good we could distinguish flatfish species apart with a high degree of certainty. Contact Paul Winger (Paul.Winger@mi.mun.ca).

Biodegradable Twine

Use of the biodegradable twine will become mandatory in 2013 for the snow crab fishery in Newfoundland. An experiment was conducted to evaluate the best natural fiber (cotton, hemp, jute, and sisal). A total of five twines were evaluated in field trials, covering a period of 124 days at liberty. The 96-thread cotton twine performed the best. Compared to the other twines evaluated, the rate of degradation for this twine was relatively quick, with a 33% reduction in the initial breaking strength recorded after 64 days, and a total reduction of 63% of the initial strength upon conclusion of the study at 124 days. Adoption of this technology should significantly reduce ghost fishing. Contact Paul Winger (Paul.Winger@mi.mun.ca).

Turbot Potting

A study is underway to determine whether baited pots can be used to capture commercial quantities of turbot (Greenland halibut). The project is being carried out in deep-water channels on the northeast coast of insular Newfoundland. Sea trials will continue this summer (2012). Contact Scott Grant (Scott.Grant@mi.mun.ca).

Northern Stone Crab – Fishery Development

Northern stone crab (*Lithodes maja*) has been reported as a bycatch species in the NAFO Division 3Ps groundfish fisheries (gillnets) for several years. Although the species is similar in size to snow crab (*Chionoecetes opilio*) it has never been harvested commercially. A project was carried-out to investigate: 1) the cpue of various prototype trap designs, 2) survival and condition using different onboard handling systems, and 3) weight and meat yield (%) at various steps in the production (cooking) of crab. Contact Philip Walsh (Philip.Walsh@mi.mun.ca).

Hake Potting

A study is being initiated to develop baited pots for white hake (*Urophycis tenuis*). The discovery that hake will enter baited pots was accidentally made during a potting project for Northern stone crab (see above). It builds on the earlier success of cod potting and there is hope it might lead to an alternative sustainable harvesting strategy for this species. Contact Philip Walsh (Philip.Walsh@mi.mun.ca).

Greenland Shark Bycatch Reduction – Longline Modification:

A multiyear study has been initiated to investigate the feasibility of longline modifications to reduce the bycatch of Greenland shark in Nunavut's (Canada) Cumberland Sound turbot fishery. The primary objective is to test the ability of 1) various gangion breaking strengths, 2) gangion length, and 3) the interval between gangions to reduce the capture and/or entanglement of Greenland shark in turbot longline gear without reducing the catch rates of turbot. Year 1 results were encouraging. Additional sea trials are planned for this summer. Contact Scott Grant (Scott.Grant@mi.mun.ca).

Greenland Shark Bycatch Reduction – SMART Hooks

Experiments were conducted in collaboration with University of Windsor to test the ability of SMART hooks (@RepelSharks; i.e. selective magnetic and electropositive alloy treated hooks) to prevent predation upon baited hooks and subsequent capture and/or gear depredation (i.e. damage to longline gear, bait, and turbot) by Greenland shark. All six Greenland shark captured during the experiment were taken on SMART hooks (5 of the 6 sharks) or in the SMART hook 20 hook replicate (1 of the 6 sharks) of the experimental longline. Further, behavioural observations revealed Greenland shark did not exhibit the typical avoidance response to a clump of electropositive alloy removed from seven of the SMART hooks. Overall, these results indicate SMART hooks are not a practical solution to reducing the bycatch of Greenland shark in Nunavut's (Canada) turbot longline fisheries. Contact Scott Grant (Scott.Grant@mi.mun.ca).

15.2.2 Fisheries and Oceans Canada – Central and Arctic Region

Greenland Shark and Arctic Skate Bycatch Reduction – Pot Traps

A multiyear experiment was initiated in 2010 to test alternative gears that could be used to reduce shark and skate bycatch in the Cumberland Sound Greenland halibut fishery. Currently, the fishery exclusively uses bottom-set longlines and primarily catches Greenland Shark and Arctic skate as bycatch. In 2010, three pot traps based on the design of the Alaskan cod pot were built and tested in Cumberland Sound as a pilot project. In a limited number of sets, the pots caught Greenland halibut and did not catch either Greenland sharks or Arctic skates. In 2012, additional pot traps will be built and tested in a full experiment to assess differences in catch rates and the commercial viability between longlines and pot traps in the Cumberland Sound fishery. Contact Kevin Hedges (Kevin.Hedges@dfo-mpo.gc.ca).

15.2.3 Fisheries and Oceans Canada – Maritimes Region

Ecosystem Effects of Scallop Dredging:

Before-after regression experiments were conducted using a scallop dredge with 16 different fishing intensities on soft and hard substratum habitats in the southern Gulf of St Lawrence, Canada. The experimental design controlled for ecosystem level changes in the abundance of benthic invertebrate taxa that were unrelated to fishing. No significant short-term fishing effects were detected in either ecosystem in single taxon and multi-taxon analyses. Broad-scale changes unrelated to fishing appeared to be more important than responses to experimental fishing. A post hoc simulation of the statistical power of the experimental design and analysis was conducted. Despite generally low statistical power to detect fishing effects at low and medium fishing mortalities, significant fishing effects were even less frequent than those expected based on the power simulation for a low level of fishing mortality (5% mortality per

fishing gear sweep). This suggests that realized fishing mortalities in the experiment were generally small. Contact: Stéphan LeBlanc (Stephan.LeBlanc@dfo-mpo.gc.ca).

15.2.4 Merinov Centre d'Innovation de l'Aquaculture et des Pêches du Québec

Eco-Pêche Program:

This project proposes accessible solutions enabling the reduction of operating costs in the shrimp, crab, and lobster fisheries in Quebec. The specific objectives are: 1) component for shrimp fishing propose solutions to reducing fuel consumption by changing practices and components of fishing gear, 2) component trap fishery (lobster and snow crab): propose solutions to reduce the cost of using bait; 3) provide to the fishers and their successors, advanced knowledge and technological tools to improve the competitiveness of their business. This program is still waiting for funding (CRSNG) and is expected to be conducted 2012–2017. Contact Jérôme Laurent (jerome.laurent@merinov.ca).

Alternative Bait Development for Lobster:

The main objective of the project is to optimize alternative bait for the lobster fishery for local production in the Gaspésie and Îles-de-la-Madeleine. The sub-project objectives are: 1) improve and adapt the recipes to local bait of two target areas (Îles-de-la-Madeleine and Gaspésie); 2) evaluate the effectiveness of baits in terms of commercial fishing; and 3) involve the fishing industry in the innovation process, to facilitate the transfer. Contact Jérôme Laurent (jerome.laurent@merinov.ca).

Kite Sail on a Shrimp Trawler:

We will install a kite sail on a shrimp fishing vessel. Because it's a first experiment of the world, the first year of the project will concern only installation and optimization of the kite system onboard. The second year will be used for quantify energy efficiency. We will record all data of navigation, fuel consumption, torque, weather (wind force and direction), of a complete fishing season. Like all new technology, specific attention will be given to safety and security. Contact Damien Grelon (Damien.grelon@merinov.ca).

Modification of Rock Crab Pots to Increase Selectivity:

Resource management is currently implemented by DFO and designed to reduce bycatch, Merinov proposes the reintroduction of selective rock crab pot in the industry. More specifically, it is suggested to change this type of pot to make it easier to bait and test the effectiveness in fishing situations. Objectives include: 1) evaluate and compare bait handling between modified and standard pot; 2) compare capture efficiency of rock crab between the modified and standard pot; 3) compare lobster bycatch between the modified and standard pot. Contact Damien Grelon (Damien.grelon@merinov.ca).

Thyborøn Pelagic Door on Bottom shrimp trawling with ACPG Innovation:

This project aims for better energy efficiency during trawling operations by using pelagic doors, "Thyborøn, model 15 VF, 3m²". By limiting or avoiding bottom contact with these doors, we expected a reduction in fuel consumption. This study will evaluate gain in consumption, bycatch and capture compare to traditional trawling. Contact Antoine Rivierre (antoine.rivierre@merinov.ca).

PDG 2: Reducing impact of Scallop Dredges on seafloor:

The main objective is to provide recommendations on possible changes to the scallop dredge and fishing practices in order to ensure a sustainable exploitation.

More specifically, we will; characterize the impact of dredging on the seabed; characterize the swimming behaviour of scallops in front of the dredge; and assess the proportion of scallops that avoided dredge, depending on water temperature and the reproductive cycle of the scallop. Contact Antoine Rivierre (antoine.rivierre@merinov.ca).

Reducing Seabed Impacts of Mobile Fishing Gears:

The main objective of this proposal is to develop an innovative fishing gear based in part on the tested innovations in recent years, and secondly on the latest technological developments concerning shrimp trawls. Specific objectives related to improving energy efficiency include a) reducing the contact surface of the foot gear; b) use of twin trawls; c) use of finer materials and more resistant to the construction of trawls. Specific objectives related to reducing environmental impact of trawling on the seabed include a) reducing the contact surface of the foot gear, and b) intensifying escape of flatfish in the trawl. Contact Antoine Rivierre (antoine.rivierre@merinov.ca).

Evaluating the effectiveness of a drag adapted to the fishing sea cucumber (*Cucumaria frondosa*) in a new fishing area in Québec:

The main objective of this project is to characterize the capture efficiency of a dredge skid designed for fishing sea cucumber, in a new fishing area in Middle North Shore of Quebec. Four specific objectives are identified: 1) Calculate the catch per unit of effort (cpue) of the dredge; 2) Quantifying the intraspecific selectivity (cucumber juveniles) and interspecies (bycatch) of the dredge; 3) Characterize the nature of the seabed and the behaviour of the dredge skid; 4) Identify changes in fishing gear and fishing techniques adjustments to improve the capture efficiency of the dredge. Contact: Sandra Autef (Sandra.autef@merinov.ca)

15.2.5 Simon Fraser University and Vancouver Island University

Underwater Camera for the Study of Trapping Gear:

A low-cost camera apparatus (dubbed TrapCam) was developed to study trapping gear *in situ*. The apparatus was constructed with off-the-shelf parts, and at a cost of ~\$3000 was able to record 13-hour videos in full HD (1080P) at depths up to 100 m. The apparatus was specifically designed to be quiet and non-invasive, making it ideal for studying behaviour of marine species in and around trapping gear. This apparatus was designed in order to study traps designed to catch spot prawns (*Pandalus platyceros*) in British Columbia, but could be adapted for other purposes. Design schematics and sample videos are included online. Contact Brett Favaro (bfavaro@sfu.ca).

Bycatch Reduction Devices for Spot Prawn Traps:

A suite of detachable bycatch reduction devices (BRDs) were designed and built in order to prevent the bycatch of juvenile rockfish (*Sebastes* spp.) in commercial spot prawn (*Pandalus platyceros*) trapping gear. These devices were curved, multi-ringed openings which clipped to the inside of the traps, and were designed to facilitate prawn entry while excluding rockfish. Field trials revealed that these devices were highly effective at excluding rockfish and other fish, while simple reductions in trap opening sizes were ineffective in this regard. However, the curved tunnel BRD's also

produced a reduction in prawn catch relative to control traps, suggesting that further refinements in the design are necessary before implementation in the fishery. Contact Brett Favaro (bfavaro@sfu.ca).

15.3 France

15.3.1 Ifremer Fishing gear technology laboratory

A project to study and improve dynamic stability of small fishing vessels.

This three-year project focuses on 12 to 25 m long fishing vessels. The objective is to develop numerical models to analyse the dynamic stability in particular hydrodynamic phenomena such as slamming or phenomena associated with possible fishing gear obstruction. A second objective is to develop electronic systems to assist the skipper in these particular circumstances. Validation is conducted using tank trials and half scale demonstrator used at sea with an important training and communication component addressed to fishers. Partners involved are engineering offices in naval architecture and hydrodynamics. Ifremer brings its skill in fishing gear simulation.

Numerical simulation: DynamiT and successor

No further development was achieved on DynamiT software (simulation of trawl gears). The successor of DynamiT is under development. It will address other types of fishing gears, DynamiT being only dedicated to trawl gears. The new software should be available in 2/3 years.

Studies in hydrodynamics dedicated to fishing gears

The 3 year HYDROPECHE project aims at improving knowledge in hydrodynamics around fishing nets. Three PhDs are based on the project. One is dedicated to automatic trawl optimization based on different optimization methods. Another aims at developing a database of tank experimental results from parallax image display (PID) images and proper orthogonal decomposition (POD) decompositions to separate the different components of flowfields (particularly the turbulent part of the flow). The third student is developing a numerical tool to calculate the flowfield around any kind of netting construction, in order to improve the fluid/structure simulation process.

Test of fish pots and Nephrops creels in the Bay of Biscay

Fish pots and Nephrops creels were lent to volunteer fishers to be tested on their own vessels. Experimental tests of fish pots on research vessels were also carried out. All results showed similar trends, with the main catches being common pout and conger eel. Some other species were also caught (e.g. whiting, sole), but not in quantities large enough to be economically viable. Further research is planned to observe fish behaviour around attractant and traps. Nephrops creels tested by fishers gave interesting results, but the main issue raised by this technique is the cohabitation with towed gears.

Selectivity of Nephrops trawls in the Bay of Biscay

Ifremer tested various selective trawl devices in the French Nephrops fishery on board a research vessel. The results were then presented to the fishing sector via the inter-regional association (Agfia). From that, two devices (square mesh cylinder and Nephrops grid) were tested at larger scale on commercial fishing vessels. These devices were then integrated to the national legislation.

EFFICHALUT

The project EFFICHALUT aimed to reduce fuel consumption in bottom trawl. This was achieved through a better understanding of the behaviour of the trawl. This better knowledge comes from i) sea trials during which the shape of the trawl was understood via measurement of warp tensions and bridles, and ii) numerical simulations. The measurement showed an imbalance between the upper and lower wings: the tension on the upper bridle was too large compared to the lower, contrary to what was expected. The numerical simulation showed the same imbalance and further exaggerated deformation of the upper wings, again not expected. From this information the fisher has proposed improvements to the design based mainly on the replacement of part of the netting of the top wing by ropes. The measurement by the fisher of consumption of fuel during few months shows a decrease of 17% of the fuel consumption of the improved trawl relatively to the reference one. The plan of the trawl from this project has already been distributed to 15 boats. The saving for the entire 15 boats is estimated at 800k€ per year.

ORCASAV

Orcasav is an innovative project to fishing in response to an environmental problem and economic. The Syndicat des Armements Réunionnais de Palangriers Congélateurs, Le Drezen, the National Museum of Natural History, Ifremer and Le Centre National de la Recherche Scientifique, grouped in a consortium, and the French Southern and Antarctic Lands (TAAF) launched the ORCASAV campaign. The objective of this 6-week campaign of experimentation fishing for toothfish was to test the effectiveness of the trap fishery, which could be an alternative or at least an extension to the technique of fishing longlines on which orcas and sperm whales have learned to predate, creating a serious economic and ecological problem. The aim of this experimental fishing with traps: to restore the ecological balance in the EEZ of Crozet Islands while ensuring the future of this fishery. The results show that a trap fishery for toothfish is feasible.

Lorient Flume Tank

The Lorient flume tank has been finished since 2011. Observations and measurements are now available in better conditions with a new monitoring system and facilities. New research projects, fishing industry testing, R&D in instrumentation, and education, are the main axes of this new flume tank.

In-situ measurements of the individual acoustic backscatter of European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*), with concurrent optical identification with EROC, the French ROTV.

The lack of specific Target Strength (TS) values for European anchovy and sardine in the literature has been pointed out by the Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VIII and IX. The need for TS measurements of specific small pelagics conducted in controlled environments was recognized by the group to further investigate the adequacy of TS length equation used to derive fish stock estimates for clupeids in European waters. Ifremer's towed body 'EROC' was used, fitted with an optical-acoustic system, to conduct in-situ TS measurements of Biscay anchovy and sardine, with concurrent optical identification. Its combination with an "open" pelagic trawl termed "ENROL" allowed for the recording of small pelagic fish TS, while controlling for the prominent factors known to influence fish TS distribution: species, length and tilt angle. Repeating EROC/ENROL-based TS measurements on monospecific schools should then allow

for the definition of accurate TS~length equations for near horizontal small European pelagic fish species.

15.4 Iceland

15.4.1 Marine Research Institute

Contact: Haraldur Arnar Einarsson (haraldur@hafro.is); Ólafur Arnar Ingólfsson (olafur@hafro.is); Einar Hreinsson (eihreins@hafro.is)

Codend size selectivity and separating species in two codends.

A collection of selectivity measurements have been made from some surveys last year. This year a survey was organized to improve this collection in selectivity from codends in use or codends with minor differences from normal. Focus will be on collecting data from fish species other than cod and haddock, like redfish and Greenland halibut if possible. In the same survey, it is planned to measure the selectivity from trawl set up with horizontal separation panel with upper and lower codend and how the system changes in selectivity using different mesh sizes in those codends. This survey will be in late June this year.

Selectivity in Nephrops trawling

Since 2007, annual surveys have been conducted on Nephrops size- and species selectivity in the Icelandic Nephrops trawl fisheries, apart from 2011. A request has been made from fisheries scientists to evaluate the performance of the currently used 80 mm diamond mesh codends. To date, such data are not available. A survey will be conducted in June 2012 on diamond mesh codend size selectivity comparing different mesh sizes and circumferences for Nephrops and fish.

Efficiency in pelagic trawling

A new study is in the starting phase with the aim to measure the efficiency of different pelagic trawls by using acoustic techniques on commercial fishing vessels. This study relies on cooperation with a fishing vessel with scaled echosounder. The depth of headline and footrope will be logged along with length of warps. Estimating from the echogram the volume of fish likely to enter the trawl compared with the actual catches will be the output from this program.

Attraction and trapping of cod

The objective of this project is to investigate cost-effective ways to trap cod. This work is based on direct observation of how cod are caught in traditional traps/pots and is divided in three phases: 1) Finding useable odour-solution to use for attraction. 2) Building of odour releaser and control unit. 3) Testing of equipment and effects of odour release. Most of the work in the project was carried out in the years 2008–2010 but progress has been slow in the year 2011 for various reasons. The projects preliminary results led to two spinoff pilot projects; “Light trap for cod” and “Grazing cod on krill (*Euphausiids*) in pens.

Remote devices (Fish Selector) in front of codend to improve selectivity

A work in collaboration with Star-Oddi, to develop a remotely operated device for improving selectivity is ongoing. The project is led by the Icelandic firm Star-Oddi with technical assistance from MRI and a commercial fishing company. A prototype has been made and tested. Further work on software programming and testing will be implemented in near future.

15.5 Ireland

15.5.1 Bord Iascaigh Mhara

Contact: Daragh Browne (browne@bim.ie)

Mesh Size Selectivity experiment with Hake Gillnets

In April 2011, BIM carried out a mesh size selectivity experiment with hake gillnets. The trial was carried out to establish the selectivity parameters of gillnets with 80 mm, 100 mm, 120 mm and 140 mm mesh size. These nets were rigged in the typical Irish/Cornish manner for hake gillnets. In addition the selectivity parameters of Spanish 100mm gillnet was also tested. The trials took place on the hake grounds to the west and southwest of Ireland and the selectivity parameters of Irish/ Cornish rigged gear (80–140mm) were similar to those reported by Revill *et al.* (2007).

Rigid and Flexible Grid in the Irish Sea *Nephrops* Fishery

A short catch comparison trial took place in December between a rigid and flexible grid in the Irish Sea *Nephrops* fishery. Results were similar to no reduction in cod separation and *Nephrops* catch. A longer term qualitative trial will evaluate the longevity of the flexible grid.

Seltra Large Mesh Escape Window in the Irish Sea

A trial of a Seltra large mesh escape window in the Irish Sea targeted ray fishery also took place in December. Results in terms of cod release were favourable although cod were not present on the ground in large numbers. Issues that were raised concerned release of high value species such as sole. Further trials will take place in 2012 but this time earlier in the season for this fishery (October to February approximately) when cod are likely to be present in larger numbers.

Fuel efficiency/ environmentally friendly fishing gear

N-Viro scallop dredges were bought at the end of 2011 for use in 2012. Reported benefits of the N-Viro dredge compared with more traditional toothed scallop dredges are: improved fuel efficiency and less seabed damage along with no decrease in catch rates. Trials are planned to investigate fuel efficiency and catch rates during 2012 on board a large offshore vessel based in the Southeast and a smaller inshore vessel based on the West coast.

Waste Management

In 2011 a total of 67,000 kg of monofilament nylon netting was exported to Lithuania and Germany for recycling into pellet form for subsequent moulding into suitable end products. Since this project began in 2005, an approximate total of 250,000 kg of waste nylon has been recycled successfully in Lithuania, Germany, Taiwan and mainland China.

BIM continued to conduct research into the viability of recycling polyethylene fishing gear and 8,000 kg of waste material was recycled into granule and powder form. Several end-products were achieved using the rotamoulding technique and these included large and small net bins, barrels and containers. Further work is being done with this recycled material and efforts will be made to reuse the material within the Fishing for Litter project which should take place in 2012. There is further potential for reusing recycled PE fishing gear in the marine environment for making usable end-products. Potential products include items such as gear-marker poles, rubbing strips (fenders) for harbours, decking for marinas and measuring boards.

Environmental Management Systems

During 2011, BIM continued to work closely with industry to further utilize the Seafood Environmental Management Systems (SEMS) developed in the last 3 years. Some 200 vessels are operating Environmental Management Systems, and, of these, almost 100 have undergone certification either to the BIM Responsibly Sourced Standard or the equivalent standard of the Marine Stewardship Council (MSC). Further development of the programme and its extension to the remainder of the offshore fleet is a priority for 2012 as is the wider uptake of the standard in the inshore sector.

Sustainability, bycatch of protected species and tuna

Irish fisheries were pre-assessed against the Marine Stewardship Council (MSC) sustainability standard to identify stock, environmental, and management issues which need be addressed in order to achieve sustainability. Collaboration between BIM, Food Certification International, Marine Institute and Sea Fisheries Protection Agency, this project provides a roadmap for fisheries seeking to adopt more responsible fishing practices, links in with the BIM Responsibly Sourced Seafood Standard and provides vital information on eligibility and steps that need to be taken to achieve MSC certification.

A dedicated independent observer programme was carried out in collaboration with University College Cork with 103 days observed in pelagic trawling operations on-board tuna, mackerel, herring, horse mackerel, blue whiting and sprat fisheries with no cetacean bycatch observed. This programme complies with EC legal requirements and supports industry in adopting a responsible approach to fishing and seeking and retaining MSC certification.

Effective dolphin deterrents (STM DDD03H) along with guidelines for their use were issued to 12 tuna vessels in the southwest. These acoustic devices have proven to be highly effective in the UK bass fishery and minimize the risk of incidental dolphin bycatch in the tuna fishery this demonstrates responsibility and improves the possibilities of certification for this fishery.

A project to quantify seal depredation and bycatch in Irish set-net fisheries commenced in collaboration with the Coastal Marine Resources Centre and MI in summer 2011 with over 50 days observer work carried out on three vessels. Levels of seal depredation (fish being taken or damaged) are being quantified with a view to informing management of interactions with this protected species with work due to be completed by the end of 2012.

A satellite tagging programme for albacore tuna continued in 2011. This project is providing enhanced information on fish behaviour to fishers to assist in detecting fish while also contributing greatly to management of the stock by ICCAT. Two fish were tagged at the end of July 2011 with very detailed information on fish depths and locations provided for the entire tuna fishing season.

15.6 Italy

15.6.1 National Research Council (CNR). Institute of Marine Sciences (ISMAR) – Fisheries Section, Ancona

Contact: Antonello Sala (a.sala@ismar.cnr.it), Alessandro Lucchetti (a.lucchetti@ismar.cnr.it), Emilio Notti (e.notti@an.ismar.cnr.it)

Green and Blue Economy: Energy check-up on-board fishing vessels.

On the basis of the experiences carried out during the e-Audit project in 2011, through the “Green a Blue economy” project, funded by the Chamber of Commerce of Ancona, Italy, many other vessels can be monitored and audited. The Energy Audit conceived at CNR-ISMAR Ancona (Italy) has been further developed and improved, focusing on the propulsion system performance which is the most heavy energy user. A report containing results, specifications about energy performance during fishing activities and suggestions on how to reduce energy use and fuel consumption, must be delivered to the fishers. Further developments of this research could be the introduction of economic evaluations about technical improvements, developing business plan for fishers, starting by their results reported in the Energy Audit Certificate.

Information collection in energy efficiency for fisheries (ICEEF project)

This project is part of the work programme for action FISHREG. JRC has already developed a pilot website on energy efficiency in fisheries that is available online at <https://energyefficiency-fisheries.jrc.ec.europa.eu/>. The site is accessible directly through the Europa website of DG MARE for fisheries. The pilot website includes reference documents and studies related to energy savings in fisheries, general information on research and funding opportunities and links to relevant EU projects, EU legislation and events, among others, the information collection is organized in many topics. Each topic reports the state-of-the-art as well as innovations which allow to achieve a sensible fuel saving. The website reports also information about the most important event related to fisheries and energy saving thus representing an interesting opportunity to spread and collect information on energy efficiency for fisheries. The most important result for this website is to become a hub of information to connect scientists, stakeholders and fishers all together.

Permanent fuel consumption survey on-board a commercial fishing vessel

A fuel consumption monitoring system was set up for research purpose in order to evaluate the energy performance of fishing vessels under different operating conditions. The fuel monitoring system conceived at CNR-ISMAR Ancona (Italy) consists of two mass flow sensors, one multichannel recorder and one GPS data logger. Fuel consumption rate and vessel speed data were used to identify energy performance under different vessel-operating conditions. The system is an effective means to monitor engine and vessel performance, but can be also used to give a real-time indication of engine fuel economy on a commercial fishing vessel. Fitting fuel flowmeters can have a positive impact on fuel consumption, particularly with respect to savings made while steaming. A valuable outcome of this experiment was that, after having installed the fuel monitoring systems the skippers reduced the steaming speed from 11.0 to 10.5 knots, and even small adjustments to revolutions (rpm) settings resulted in significant fuel savings of around 10–15%.

New integrated fisheries management system in Europe (ECOFISHMAN)

EcoFishMan is a three years project seeking to develop a responsive fisheries management system (RFMS) based on results-based management (RBM) principles. The context of application of the RFMS is complex, mixed-fisheries and multistakeholder fishery sectors like those found in the EU/Common Fisheries Policy (CFP) area. It will be an ecosystem-based sustainable management system under a precautionary framework that will define maximum acceptable negative impact, target elimination of discards and maintain economic and social viability. EcoFishMan is a multi-disciplinary project, involving scientists and stakeholders in activities relating to biology, stock assessment, technology, economy, sociology and legal aspects of fisheries management.

Mediterranean halieutic resources evaluation and advice (MAREA)

A Joint Consortium has been created for the objectives of tenders MARE/2009/05 - LOT 1 - Mediterranean. The Joint Consortium, led by CoNISMa, will provide Scientific advice and/or other specific preliminary services according to the following Terms of References:

- Assessment of the state of aquatic living resources and advise on fisheries management scenarios
- Ecosystems knowledge and its integration into fisheries management
- Monitoring of specific fisheries and fishing gears not included or insufficiently covered in the data collection framework or for which such a work has not yet been done or is not going to be done on the short term or on a regular basis
- Effects of pollutants and of other human activities at sea on aquatic leaving resources and fisheries

The services may include the collation of existing scientific and bibliographic information, the collection of new scientific and technical information, including, where appropriate by carrying out surveys or trials at sea and in the ports, the carrying out of scientific evaluations and modelling, the analysis of data quality, identification of and access to independent expertise and studies.

Innovation in production systems and techniques for fishing and aquaculture (MARTE+)

The project provides for the establishment of a Scientific-Technical Working Group, composed of persons representing the four regions of the border area (Corsica, Liguria, Tuscany and Sardinia), with the following duties:

- analysis of fishing systems in use 'nell'areale' border to assess the positive and critical aspects;
- setup of specific experiments of innovative sustainable systems/gears and take into account the requirements and regulations regarding the needs of the regions involved in terms of traditional fishing activities of fishing communities, socio-cultural and environmental.

In particular, this project claims to proceed with testing of nets to catch some species of commercial interest, including the testing of technical equipment available to enhance the selectivity, used mainly in coastal fishing with small boats.

Assessment of the protected species bycatch in pelagic trawl (BYCATCH IV)

The project aims at evaluating the bycatch of protected species in pelagic trawl. The second goal of the project was to find solutions to avoid the bycatch of protected species. Pelagic trawlers in the Adriatic Sea only target small pelagic species (Anchovy and Sardine). CNR-ISMAR carried out several observations on-board finalized at monitoring the catch and the eventual bycatch.

In order to reduce the bycatch in pelagic trawl a modified TED (*Turtle Excluder Device*) was developed and adapted to a single boat pelagic trawl. The preliminary results are encouraging. Next step will be to test the TED in a pair trawl which is the main activity in the Adriatic Sea.

15.7 Japan

15.7.1 Fishing Technology Laboratory, Graduate School of Fisheries Science and Environmental Studies, Nagasaki University

Yoshiki Matsushita (Report compiler; yoshiki@nagasaki-u.ac.jp)

Monitoring squid jigging fishery for better application of LED lighting technology

LED surface lighting devices were introduced to 9 squid jigging boats. We have been collecting logbooks containing information about; Date, Time, Position, Lighting condition, Fuel consumed, Catch amount, etc. Squid catch data in other conventional operations has simultaneously been collected. Analysis of information provides not only a performance of LED, but also ideas of how to utilize installed LED. The step-wise lighting method termed "stage reduced lighting", that turn on all lamps at the beginning of operation and reduce amount of light as time elapsed was confirmed as fuel saving techniques. National project during 2009–2011.

Monitoring purse-seine fishery for better application of LED lighting technology

Surface and underwater LED devices were equipped to the lighting boat of coastal purse-seine fleet and in operation in anchovy fishing for approx. 2 years. This boat attracts fish at the same level of conventional lighting. Cooperative project with fishers, fishermen's cooperative and local government.

Investigation on fish search/attracting strategy in purse-seine fleets

Another problem of purse-seine fishery in the region is about high labour and operation/maintenance costs. The newly designed main-boat which has fish storage was built by subsidy from National government. This design enabled operation with less numbers of boats in the fleet (5→4 boats). Also sharing lighting boats with other 4 fleets has started to reduce operation costs. We have just started this project, but planning to monitor movements of lighting boats to investigate temporally and spatially optimized distribution of these boats.

Development of monitoring methodology of sessile organisms' bycatch in bottom fishing

This is granted the ministry of science, technology and education. We design bycatch data collection survey in cooperation of fishers using trawls, gillnets and longlines that contact seabeds. We provide GPS data loggers and waterproof digital cameras to volunteer fishers and request them to take pictures of captured sessile organisms. By analysing data, pictures and characteristics of fishing methods, we aim to detect hot points where to be protected.

Monitoring derelict fishing gear in the East China Sea

Cooperation project with Seikai national research institute of fisheries, fisheries re-search agency. We have been collecting fishing gear captured in the trawl during the East China Sea groundfish survey for 4 years. We accumulate data on type of fishing gear and their geographical distributions, ghost fishing.

Human resource development program for fisheries in Nagasaki

Nagasaki University has been conducting education program for fishers and person working in fisheries industries (administrators, fish processors, etc.). Lectures and other activities are carried out both in the University and fields where students are working approx. for 170 hrs in 2years. This is free of charge and we accept approx. 10 students every year.

15.7.2 Nagasaki Prefectural Institute of Fisheries

Daisaku Masuda (masuda.daisaku@pref.nagasaki.lg.jp), Shuya Kai

Topography, flow and fish behaviour surveys in fish trap fishing grounds

Responding to fishers' demands, topography, flow condition and fish behaviour surveys using a sidescan sonar, acoustic current profilers and a scanning sonar have been carried out around fish trap fishing grounds. This survey provides basic data on fishing effort allocation of fish traps for the local governments. And also provides suitable locations and constructions of fish traps for fishers.

Investigation of the low-power underwater fishing lamp in large-scale fish trap

To improve catchability of fish traps, application of the low-power (55W) underwater lighting was tested in the large-scale fish trap. The lamp was set in front of the leader net and turned on in the night-time for 6 hrs. Alternative haul experiment was done approx. for 150 days while electricity was supplied from surface battery unit which was maintained at the time of hauling. Significant increase in catch was observed for total catch, chub mackerel, horse mackerel, round herrings, and swordtip squid.

Investigation of underwater light for squid jigging fishery

To improve catchability and energy efficiency, use of underwater lamp was tested for squid jigging fishery. Lighting directivity was adjusted by attaching the hat to the lamp to create shades in the specific water layers. However GLM analysis suggested that the underwater lamp has negative effect for catching squids.

15.7.3 Department of Fisheries Science, Faculty of Agriculture, Kinki-Daigaku University, Study Group of Fishing Technology and Fish Behaviour

Tsutomu Takagi (tutakagi@nara.kinidai.ac.jp, Kinki-Daigaku Univ.), Shinsuke Torisawa (Kinki-Daigaku Univ.), Minoru Kadota (Kinki-Daigaku Univ.), Kazuyoshi Komeyama (Kagoshima Univ.)

Application of NaLA: a numerical simulation system for fishing gear geometry and acting loads

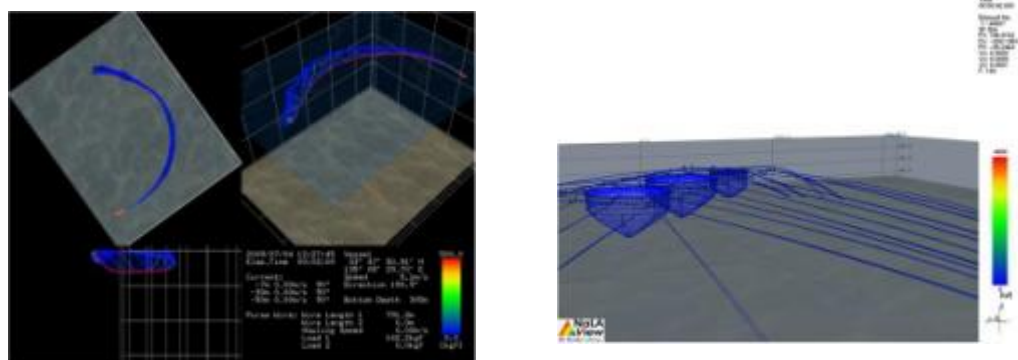
NaLA is a numerical simulation system for fishing gear geometry and acting loads that has been developed and applied in some projects for the dynamical analysis of fishing gears. The numerical simulation system consists of a preprocessor, and a calculation kernel and viewer for numerical results. The preprocessor generates numerical data from a design drawing to facilitate computation using a numerical model.

*** Practical application of NaLA: simulation system for purse-seine fishing**

NaLA has been installed on the purse-seine fishing vessel to monitor underwater purse-seine netting in real time during operation. To run the numerical computation, information regarding the current velocity, sea depth, purse wire length, vessel course, and speed can be input into the NaLA PC. The numerical model of the purse-seine netting consists of some large triangle netting panels for high-speed computation in real-time simulations.

***Application for large offshore aquaculture facility**

The geometry and load of multiple allocations of the offshore aquaculture facility have been estimated using NaLA. The numerical simulation gives the optimum design layout for practical use.



Measuring the swimming behaviour of Pacific bluefin tuna and three-D path reconstruction technique

The special multi sensor tag, which can measure fish swimming speed, depth and heading, calculated using geomagnetism and the tilt sensor, can be developed and installed into body of PBTs. After retrieved the tags, the time-series data of the swimming speed and the heading angle were used to reconstruct the location on x-y plane in each time-step by using band path filtering technique and then 3-D path can be produced by added the depth data. The combination of different archival tags can advance the function as a dead reckoning.

Assessment technique for fish behaviour by using relative entropy

Archival tag can collect a large amount of time-series data. However it is difficult to assess modifications in fish behaviour and quantitatively evaluate through such a large digital data. This assessment technique has been developed by using the relative entropy from the perspective information theory. This is able to assess modifications of behaviour in swimming speed or depth data due to for example traumatic stress or external stimulus.

15.7.4 School of Fisheries Sciences, Hokkaido University

Yasuzumi Fujimori (fujimori@fish.hokudai.ac.jp)

Estimation of selectivity and efficiency of commercial fishing gear and sampling gear

Development of the suitable sampling techniques for fish and plankton in acoustic survey

Reducing fishery damage by Northern fur seal using acoustic device

Monitoring of bycatch of juvenile walleye pollock in set-net fishery near Funka-Bay in Ho

15.8 Netherlands

15.8.1 IMARES/ILVO

Contact: Bob van Marlen (bob.vanmarlen@wur.nl), Dick de Haan (dick.dehaan@wur.nl)

ICES research on pulse trawling

IMARES and ILVO started a follow-up project with representatives from the fishing industry, pulse trawl producers, and the Dutch Ministry to address problems concerning control and enforcement in shrimp and flatfish pulse trawling developments. Participation from control agencies was strengthened. A new procedure is currently under development.

In May 2011 comparative fishing trials will be undertaken of two pulse trawl boats (system PulseWing by HFK Engineering and system pulse trawl by Verburg-DELMECO) and a conventional beam trawler fishing nearby. The results were analysed thoroughly and a publication prepared. IMARES made reference field strength measurements on-board two representative pulse trawlers in November 2011 with gears laid on the bottom. The data were used in the analysis of this catch comparison.

Institute: IMARES. Contact: Mascha Rasenberg (mascha.rasenberg@wur.nl)

Project: Pulse trawling monitoring program

IMARES started in December 2011 with a pulse trawling monitoring programme, which will continue for one year. The objective of this programme is to get more insight in the catch composition of the pulse trawling fleet, which aims at catching flatfish. The project exists of two programmes, an observer programme and a self-sampling programme. In the observer programme, ten observer trips will be done by IMARES and ILVO. In the observer trips, the observers follow the standard discard protocol, which is also used for trips for the EU Data Collection Framework. In the self-sampling programme, 20 vessels will collect data on their catch according to a standard protocol. Analysis of the collected data will be done in March 2013.

Institute: IMARES/ILVO. Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

Project: Shrimp Pulse Trawl

The Shrimp Pulse Trawl project was continued with testing the Belgian "HOVER-CRAN" (low impact shrimp pulse trawl) on three Dutch vessels. ILVO and Marelec from Belgium are involved.

Institute: IMARES. Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

Project: VIP Pulse cable

This project was continued, but the cable producer De Regt was taken instead. First new cable prototypes were developed and tested at sea.

Institute: IMARES/ILVO. Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

Project: VIP Skipper Network SumWing South

In the SumWing project constructional improvements are designed and tested to reduce structural damage. Some skippers changed to the integrated PulseWing system, in which SumWing and pulse trawling are combined.

Institute: IMARES. Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

Project: VIP Skipper Network Discards South

This is a new project with beam trawl skippers of the southern Dutch ports. Its purpose is to address the problem of discarding by exchanging information on fishing gear and practices and addressing the deck handling of catches on board. Shipyard "Maaskant" is involved in designed a so-called catch separator system, in which debris will be filtered out before it will affect catch, thus improving the chances for survival of discards. A number of beam trawler skippers were interviewed to retrieve their knowledge and experience in reducing discards. IMARES/ILVO will participate in trials on the catch separator system, and measure discard survival.

Institute: IMARES. Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

Project: VIP Skipper Network Net Innovation South

This is a new project also with beam trawl skippers of the southern Dutch ports. Its purpose is to address the problem of discarding by exchanging information on fishing gear and practices.

Institute: IMARES. Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

Project: VIP T-Line

This is a new project with beam trawl skippers from Urk. The T-Line concept is a trawl using pins instead of chains to chase fish out of the seabed. A first trial was done in December 2011 with T-Lines integrated in a SumWing, but the pins had a tendency to break off and catches of particularly sole were not satisfactory. A new version will be tested later in 2012.

Institute: IMARES/ILVO. Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

Project: VIP HydroRig

This project was rounded off with a final report in 2011. A follow-up was proposed and is still pending. Higher prices of plaice would stimulate its continuation.

Institute: IMARES/ILVO. Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

Project: VIP Passive Gear Development

This project was rounded off with a final report in 2011.

Institute: IMARES. Contact: Bob van Marlen (bob.vanmarlen@wur.nl), Leeke van der Poel (holland.hydro@knoware.nl)

Project: VIP ViBOS

The project is still delayed by financing problems.

Institute: IMARES. Contact: Bob van Marlen (bob.vanmarlen@wur.nl), Hans van de Vis (hans.vandervis@wur.nl)

Project: VIP PALSED

The prototype stunner in which fish can be fed by hand was tested in the laboratory of IMARES on plaice, which showed difficult to keep alive. The Norwegian company was involved in making a prototype that was tested on-board the commercial fly-shooter. First results indicated that some adjustments are necessary to keep the flow of fish through the stunner steady. Detailed observations are planned in 2012.

Institute: IMARES/ILVO. Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

Project: VIP VDTN By-catch Reduction by Technical Means

As follow-up of earlier projects with Benthic Release Panels and Benthic Release Holes a new project was set up with three commercial beam trawlers. Idea is to bring together a number of skippers, exchange ideas, test new adapted versions first on FRV "Tridens", and then conduct practical trials on the commercial boats to fine-tune these devices. This work is also done in cooperation with ILVO. Financing problems cause a delay of this project.

Institute: IMARES. Contact: Floor Quirijns (floor.quirijns@wur.nl)

Project: Cooperative Research Platform

This project is all about cooperation between the Dutch Ministry for Agriculture, Nature and Food Quality, the Dutch Fisheries Product Board and IMARES. For several year's fisheries managers, fisheries representatives and fisheries scientists have been working on improving cooperation for a better management of the Dutch demersal fisheries. First there was the 'F-project', which aimed at improved stock assessments; better use of fisheries' dependent data; and communication between all parties (2002–2007). Then, in 2008, a platform for Cooperative Research was set up. In the platform representatives of the fisheries, managers and scientists take place. Their common objective is to coordinate all ongoing projects that are relevant to management and to share information. Several issues are being dealt with in the Cooperative Research Platform, e.g. validity of research surveys, collaboration in discards monitoring, setting up an industry survey etc. A structural way of communication improves cooperation between parties and has a positive effect on innovative trajectories in fisheries management. The platform is funded by both the Ministry and the Product Board.

Institute: IMARES. Contact: Floor Quirijns (floor.quirijns@wur.nl)

Project: Industry involvement in research surveys

In the framework of the Cooperative Research Platform a new role was established for the industry in research surveys that are used for plaice and sole stock assessments (Beam Trawl Survey and Sole Net Survey). Fishers cooperated with scientists to check the survey nets before the surveys started and fishers joined the survey on-board of the research vessel. This resulted in more insight in the surveys from a fishers's point of view and a higher quality of the discussion between scientists, fisheries managers and fishers about the survey.

Institute: IMARES. Contact: Floor Quirijns (floor.quirijns@wur.nl)

Project: VIP Industry Survey: Phase 1

In 2009 the first phase of the Trajectory Industry Survey was carried out. In this trajectory fisheries managers, fishers and fisheries scientists investigate whether an industry survey – in addition to research surveys – for plaice and sole is useful. It is

being investigated how such an industry survey should be set up and how it may influence fisheries management.

The first phase showed that comparative fishing between research vessels and a commercial vessel is feasible and that there is sufficient support for an industry survey from (international) scientists, fishery managers and fishers. A request for funding of phase 2 was submitted in March 2010. In that phase the comparison of length frequencies of plaice and sole will be finalized.

Institute: IMARES. Contact: Floor Quirijns (floor.quirijns@wur.nl)

Project: VIP Industry Survey: Phase 2

In 2010 the second phase of the Trajectory Industry Survey was carried out (see previous project). The objective of the second phase was to compare catch composition of research vessels and a commercial vessel, while fishing alongside during the Beam Trawl Survey (BTS). Length frequencies of plaice and sole were compared. It appeared that all length classes are caught by both research and commercial vessels. This resulted in the conclusion that the BTS is good enough for getting a signal on developments in the plaice and sole stocks. A commercial vessel however, does of course catch a lot more plaice and sole per unit of fishing effort. Therefore it is expected that a survey with commercial vessels, fishing at commercial speed using commercial gear, would result in more information on plaice and sole. More information would help to get less uncertainty in estimates of recent stock developments. Eventually this may reduce inter annual variation in estimated stock size and TAC advice.

Institute: IMARES. Contact: Mascha Rasenberg (mascha.rasenberg@wur.nl)

Project: Annual Industry Survey: phase three

The outcomes of phase one and two led in 2011 to the start of the annual industry survey. The working plan/protocol for the survey has been set up in close cooperation with the fisheries sector, managers and researchers. The objectives of the industry survey are: 1) collect extra information on sole and plaice for more certain stock assessments; 2) to increase the confidence of the fisheries sector in stock assessments; 3) to cover a large part of the North Sea, which is important for commercial beam trawl vessels.

In 2011 the industry survey has been executed for the first time. Two beam trawlers have sampled 80 hauls in 22 ICES quadrants. The target species were sole and plaice.

Each year, the industry survey will be executed in the same way. When a data range of five years has been collected, the analysis of the collected data could be used for stock assessments on sole and plaice which are executed by the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak.

Institute: IMARES. Contact: Floor Quirijns (floor.quirijns@wur.nl)

Project: Fishery Study Groups ('Knowledge Circles')

Fishery Study Groups are (study) groups of fishers and fish farmers who formulated challenges, questions or problems in their fishing or fish-farming activity. Together they look for solutions to make their fishery more sustainable: both from an economic and ecological point of view. There are currently 12 Fishery Study Groups, working on various fisheries in the Dutch sea, lakes and rivers and on farming of oysters or fish. Issues that are being dealt with are e.g.: gear development (pulse trawl, Sum-Wing, outrig, fly-shooting, static gear, Nephrops trawl and shrimp (*Crangon crangon*

L.) trawl), reduction of bycatch or discards, increasing knowledge of target species, reduction of fuel costs and improving cooperation between fishers and retailers.

Institute: IMARES. Contact: Frans Veenstra (frans.veenstra@wur.nl)

Project: Fishery Study Groups Fly-shoot fisheries

Since 2008 Dutch fly-shoot skippers from the North and the South (about 16) are working together in a Fishery Study Group exchanging practical experiences and discussing problems. Besides communication and marketing aspects they are interested in improving their fishing techniques. A group of fly-shoot fishers visited Icelandic colleagues, the Marine Research Institute and flume tank, as well as netmakers. The technical questions are related to creating more sustainable fisheries and improving fishing techniques, with specific interest in the behaviour of seine ropes on different grounds. Flume tanks are too small for scaling these ropes (2 x 1500 m) correctly for model testing. It was investigated whether other facilities could be used, such as model basins used in naval studies (e.g. of MARIN the Netherlands), but this appeared to be too costly. Discussions are still ongoing about whether to make use of ROV's and/or underwater cameras or even mini-submarines for direct observations.

The Dutch netmakers and skippers are also interested in user-friendly net design software. Contacts with SINTEF and Ifremer were made. A workshop on fly-shooting using combined simulation and flume tank model observations was held in 2011.

Institute: IMARES. Contact: Josien Steenbergen (josien.steenbergen@wur.nl)

Project: Cod Catches in the Nephrops fisheries

This project consisted of two different parts:

The Dutch government closed the Botney Gut in December 2010 for three months for all TR fisheries to protect the cod stock. The Nephrops fishers wanted an exemption of this closure because this is an important fishing area for them and in their own words, they do not catch cod. Through a pilot study in 2011, information has been collected on the cod catches of these fishers. Eight trips have been samples by five different vessels. This resulted in average cod catches of 2–5 per hour.

But also the opportunities to further reduce the cod catches are investigated. With a literature review study, different gear modifications were searched that could be used to let the cod escape from the fishing nets, so that catches of cod can be reduced. These modifications need to be tested in pilot studies to see if they have potential.

Institute: IMARES. Contact: Josien Steenbergen (josien.steenbergen@wur.nl)

Project: VIP Sustainable fisheries on North Sea Crab

The objective of the project is to collect data on the North Sea Crab Fisheries and its discards for a better understanding of the relationship between fishing pressure and the crab stock. The results about the crab and the stock are coming from the literature, existing data and knowledge at IMARES and from collected data from a fisher.

15.9 Norway

Unaccounted mortality of Norwegian spring-spawning herring crowded and slipped in purse seine fisheries

Full-scale survival experiments were carried out with Norwegian spring-spawning herring at the southwest coast of Norway in March 2011 and 2012. Herring were caught with purse-seines and carefully transferred to four large holding pens without breaking up the natural schooling behaviour. One pen was kept as control, while the fish in the three other pens were crowded to different densities for 10 minutes. Three replicate crowding experiments were carried out. The results showed that the mortality of herring (*Clupea harengus*) after exposure to hard crowding and subsequent slipping from purse-seines may be unacceptably high. The mortality rate five days after slipping was proportional to crowding density, reaching 36% in the hardest crowded group. The mortality rates in the control groups varied between 1.1 and 4.5%. These results shows that slipping after hard crowding should not be allowed as a means to regulate herring catches, and suggest a need to revise the legislation on slipping in these fisheries. However, the experiments also showed that herring may survive slipping from purse-seines well if handled gently and released at an early stage of pursuing. Contact: Aud Vold (aud.vold@imr.no).

Development of Trawl simulation software (CATS 2)

The objective of this project is to update the simulation software CATS which was made in the mid 1990s to a new version where more fishing gears can be analysed. The updated software can be used for analysis of trawls and seines with diamond, hexagonal meshes and or nets incorporating square mesh sections. The software can handle a number of different operations like trawling in either single or multi trawl configurations. The updated software will also be able to handle the seining process of a Danish Seine. Contact: Kurt Hansen (kurt.hansen@sintef.no).

Selectivity in midwater trawling for cod

Full-scale experiments to assess the selectivity of different selection devices have been performed on board the commercial trawlers "Atlantic Star" (in 2010) and "Ramoen" (in 2011). The results showed that the selectivity of a 138 mm T90-codend and that of a codend with 130 mm Exit Windows gives stable and encouraging good selection in midwater trawling for cod. Both codends proved to be effective to sort out small fish under extremely high catch rates of fish (up to 5 tons of fish per minute). Both caught in average less than 2% of undersized fish in areas which had up to 32% of undersized fish. A 55mm sorting grid showed capacity problems at high catch rates. Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Mapping of potential solutions to reduce ghost fishing

This project was aimed at generating solutions to reduce/avoid the effect of ghost fishing. Regarding avoid loss of gear, it was proposed to i) develop an intelligent buoy that transmits information (gear, position, owner, dates, etc) to all traffic in the area; ii) develop a program for forecasting deep-water currents (direction, intensity, etc) in the most used fishing grounds for gillnetting in Norway. In addition, it was suggested to develop an application for calculating drifting of the gear. Regarding methods for recovering of lost gear, it was proposed using available underwater telemetric tracking technology. Finally, it was suggested studying the fishing properties of new biodegradable plastic materials in certain parts of the gear (use of PBS monofilaments, for instance).

Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Development of catch control device for midwater trawling

This 3-year project is aimed at developing prototypes of catch control devices that could help controlling the size of the catch and that gently release the excess of fish at the same fishing depth. The working principle of these prototypes is based on a codend that closes and partially detaches from the rest of the trawl when it has been filled with a certain amount of fish. In this way the fish that is still inside the belly of the trawl have the chance to escape unharmed. Two prototypes, each having a different release mechanism, were developed and tested at sea in April 2011 and March 2012 giving encouraging good results.

Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Development of multirig semi-pelagic trawling

The main objective of this 3-year project is to increase energy efficiency of the Northern shrimp fishery and northeast Arctic cod fishery. This will be achieved by: Developing a multirig semi-pelagic trawling for single, twin and triple trawl; developing a trawl surveillance concept based on state-of the art trawl sensor technology; developing a gear control system mainly via enhanced winch control and vessel manoeuvring control; developing a light groundgear based on a combination of skirt-, brush- and self-spreading groundgears.

Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Random pairing as an approach to measure selectivity in commercial-like trawl fisheries

Trawls are one of the most widely used fishing gears around the world because of their flexibility and capacity to adapt to almost any fishery, type of seabed and weather conditions. The limitations and challenges often encountered by the scientists when working at sea have had as consequence the development of different sampling methods. In fisheries where the covered codend method cannot be used and the paired gear method cannot be applied the so called alternate haul method is often used. The study of selectivity in big pelagic trawlers is among the most challenging within trawl selectivity studies. The fact that the catches in these types of vessels are often big (>30 tons) have implications on the use of the covered codend method and the paired gear method. Converting the gear from a control to a test gear (necessary to apply the alternate haul method) and the steaming required carrying out the control and the test hauls parallel can become time consuming processes that commercial vessels cannot afford. Consequently, a bulk of control hauls are often first collected followed by a bulk of test hauls, which later need to be paired. In trials carried out in this manner the amount of collected control hauls do not always match the amount of collected test hauls (unbalanced hauls) and in this situation there is a tendency for the hauls that cannot be paired to be discarded. Practical limitations often lead to analytical challenges and the data collected in this way often need to be analysed as pooled hauls (all control hauls and test hauls are pooled separately and then analysed as a single haul) or as individual hauls where the first collected control is "artificially" paired with the first test haul, the second control is again "artificially" paired with the second test, etc. Both of these procedures have analytical deficiencies mainly linked to the estimation of the confidence limits of the mean selectivity estimate values. This investigation is a selectivity study where the performance of a sorting grid system, a T90 codend and a codend with EW is compared using the alternate haul method in the Norwegian pelagic trawl cod fishery. The work proposes a

method to cope with some of the challenges of running selectivity studies using the alternate haul method in trawl fisheries in general and pelagic trawl fisheries in particular. The method of random haul pairing presented i) overcomes the problems of having with unbalanced control and test hauls and ii) deals with the challenge of confidence interval underestimation.

Contact: manu.sistiaga@sintef.no, bhe@aqua.dtu.dk or eduardo.grimaldo@sintef.no.

Understanding the Size Selectivity of Redfish (*Sebastes spp.*) in North Atlantic Trawl Codends

The majority of trawl selectivity studies for the three redfish species of particular commercial importance in North Atlantic fisheries: *Sebastes marinus*, *Sebastes mentella* and *Sebastes fasciatus*, are based on data collected from diamond mesh codends with mesh sizes ranging from 88 mm to 147 mm. We demonstrate how results from these studies can be understood by morphological characteristics of the species. We predict codend size selection based on morphological data collected from golden redfish (*S. marinus*) individuals. Further, consistent with previously reported morphological similarities between the three redfish species, we show the predictions for *S. marinus* may successfully be extrapolated to understand experimental codend size selectivity results reported for *S. mentella* and *S. fasciatus*. In addition to the comparison with previously reported data, we present new experimental results for a codend applied in Northeast Atlantic redfish trawl fishery. Contact: bhe@aqua.dtu.dk or Manu Sistiaga (manu.sistiaga@sintef.no). Article published at the NAFO Journal.

Pots for the north Norwegian shrimp fishery

Pots are successfully used in North America and the Baltic Sea to capture *Pandalus borealis* and other similar shrimp species. Pot-captured shrimp give superior quality and can be a source of extra income for coastal fishers that in the last decade have struggled through periods due to a combination of low fish prices and high fuel prices. The study was carried out in cooperation with a coastal fisher in Malangen fjord (North of Norway). The trials were carried out in June and in the same fishing area where the small coastal vessels regularly trawl. The catch rate of the pots was too low to draw any conclusions on the efficiency of the pots but the results of the study showed that bait conservation is one of the main challenges to establish such a fishery in Norway. The study was a small pre-project funded by the Norwegian Research council. Further studies covering different fishing seasons and areas are recommended in the near future. Contact: Manu Sistiaga (manu.sistiaga@sintef.no).

New fuel- and catch efficient active fishing gear concepts based on trawl and seine

A project was started in 2009 and running to 2012, with the aim to reduce NO_x- and other environmental emissions and impacts from demersal fisheries, by proposing new fuel- and catch efficient active fishing gear concepts based on trawl- and seine technology. The project shall propose new rational fishing strategies and develop new, feasible gear concepts in close cooperation with fishers and the fishing industry, through workshops, lab tests and numerical simulations, including aspects such as net design, towing resistance and catch efficiency, including among other things a PhD in Operational Analysis. A matrix of potentially interesting combinations of nets, spreading devices and groundgear for bottom trawls, (semi-)pelagic trawls and (Scottish) seines has been established and tested in the Hirtshals flume tank, and some of these will be followed up with full-scale trials. In addition a dynamic trawl simulation tool is being extended to handle seine-like operation. Contact: Svein Helge Gjosund (Svein.H.Gjosund@sintef.no).

Development of a Pelagic Survey Trawl – Multpelt 832

Gear technologists, commercial trawl designers and researchers responsible for pelagic fish stock assessment in Norway, Iceland and Faroe Island have agreed on a common design of a pelagic trawl, and how it should be operated during surveys for the mackerel stock in the Norwegian Sea. The trawl design was refined in a process where all partners were involved. In 2012 the three Nordic countries will utilize the Multpelt 832 trawl and the agreed trawling strategy to estimate the mackerel stock with a swept-area method. The pelagic trawl has a circumference of 832 m in the entrance, having 16 m in the front part decreasing to 60 mm in the codend. While surface trawling for mackerel 350 m of Dyneema warp rope is used in front of the trawl doors, and towing speed is generally 5 kn. Bridle lengths are 80 m. Contact: John Willy Valdemarsen (john.willy.valdemarsen@imr.no)

CRISP

The Centre of Research-based Innovation in Sustainable fish capture and Processing technology is an arrangement where Norwegian research institutes, universities, fish equipment producers and sales organizations cooperate to develop efficient and environmentally friendly fishing methods. Institute of Marine Research is hosting the centre, which have got long-term funding (5 + 3 years) from the Norwegian Research Council. The center started its R&D activities in April 2011, and it has already made significant progress in developing new instrument solutions and trawl components. Contact: John Willy Valdemarsen (john.willy.valdemarsen@imr.no).

Acoustic measurements of school biomass and fish size

IMR cooperates with partners (Simrad AS) within the CRISP program to enable modern fishery sonars to more accurately measure fish school biomass before and during seining. Determining the size of individual fish inside schools and in layers is also a long-term research goal within CRISP, using new broadband echosounders. Contact: Egil Ona (egil.ona@imr.no).

Low impact trawling

IMR cooperates with producers of trawl doors and gear monitoring instruments to develop trawl doors where horizontal and vertical forces acting on each door can be adjusted while fishing. By using hatches above and below the towing bracket that can be opened and closed 40% reduction of spread force were achieved when all hatches that had a surface area comparable to 20% of the trawl door surface, were opened. The trawl doors rolled approximately 40 degrees inward and outward, respectively, when the upper and lower hatches were opened. The rolling of doors creates a significant lift and diving performance of the trawl doors. Next step is to develop a motorized system that can adjust the opening of hatches independently through acoustic links between each door and the vessel. A basic idea behind this trawl door development is to be able to manoeuvre each door independently when towing both doors off-bottom in a semi-pelagic rigging and thus reducing trawl door bottom impact.

IMR is developing a pelagic/semi-pelagic trawl design that minimizes drag and increase the catching performance. One component in this development is to use brick shaped meshes made from hexagonal meshes in the aft belly part of the trawl. Preliminary tests of this netting have indicated interesting performance with regard to maintaining geometry of the trawl belly and reduced meshing of smaller fish. Contact: John Willy Valdemarsen (john.willy.valdemarsen@imr.no).

DeepVision Technology

IMR continues to cooperate with a commercial partner (Scantrol AS) on development of a camera-based system to identify and measure individual fish inside a trawl. Preliminary results indicate lengths estimated using the camera system are within 5–10% of manually measured lengths. Procedures have been developed for measuring fish even when the entire fish is not visible or it does not present a side-on view to the camera. Images can be streamed live to the vessel's bridge and are saved for later analysis. The system can be a useful tool to verify size and species stratification by depth during acoustic surveys. A new, more compact, system capable of operating at up to 2000 m depth is being readied for field trials in May and software development to further automate image analysis is underway. Contact: Shale Rosen (shale@scantrol.no).

Combined camera and trawl sonar technology

IMR continues with the one of the main partners of the CRISP, Simrad AS, to develop and improve the communication between the trawl and the vessel on standard trawl sonde cables, for data transfer of video and acoustic data to the bridge. Simultaneous video and trawl sonar data can then be used for the skipper catch decisions. The trawl sonar will work as a data node in the network of sensors on the trawl. Contact: Arill Engås (Arill.Engaas@imr.no).

Reduced by catch of bottom fish in the small-meshed trawl fishery for blue whiting and Norway pout

The experiment with grid sorting systems in bottom trawls for Norway pout in the Norwegian Trench was finalized in 2011, with further tests of flexible grids with rectangular and drop-shaped bars. While the rectangular bars gave poor water flow through the grids, the relative thin drop-shaped bars did not stand the mechanical forces exerted onto the grid system, giving irregular s-shaped bars. There was only a minor loss of target fish in the last version, but irregular bar distance resulted in a few big saithe passing through the grid.

Flume tank test will be performed in 2012 of all the grids tested in this Fishery; the Faroese Flexi-panel, stainless steel grids, and two different flexible grids (Carlsen Net).

In 2011 grid system with 40 millimetre bar distance were introduced on a general and compulsory basis in the fishery for blue whiting and Norway pout in the Norwegian trench. Only those boats that could prove taking care of demersal fish as saithe, is still allowed to fish without grids installed. From mid 2013 all vessels have to work with grids installed in this small-meshed fishery in NEZ in the North Sea. Contact: Bjørnar Isaksen (bjoernar.isaksen@imr.no).

Improved purse-seine technology to avoid crowding and reduce slipping mortality in the fishery for pelagic species

In 2011 work continued on methods to get samples of purse-seine caught fish on deck in an early stage in the purse seining process, and well before crowding. Net pockets, both natural and pockets sewn onto the net wall of the purse-seine gave samples, but not on a regular basis. An extreme pocket with an opening area of five by five meter of transparent polyamide netting was thought to fake a hole in the net wall, but video observation demonstrated that the herring did not interpret this "invisible" netting as a hole. A work has recently started on a sampling device/small trawl being deployed by air gun, 30–40 meters away from the purse-seiner and into the purse-seine net.

Work on video equipment for purse-seine has continued, with rough housing that do withstand the wear and tear of both the shooting of the purse-seine as well as being hauled through a Triplex, and will be refined during coming experiments.

In cooperation with the fishing industry, different parts of the end of the purse-seine ("bunt") are now being modified; mostly to secure that pelagic fish easily can be slipped from purse-seine in case of too big catches or due to wrong size or quality. Well proven technique from the days of live fishing and storage of sprat and mackerel is being revived and incorporated in the purse-seine used for pelagic species. Contact: Bjørnar Isaksen (bjoernar.isaksen@imr.no).

Development of a coastal fishing vessel concept (Danish Seiner, Loa = 14,99m) for catch and freight of living fish

An outline specification and a preliminary general arrangement of a 14,99m Danish seiner are developed in cooperation with Mikal Steffensen. The vessel has been priced by a Norwegian shipyard, and Mikal Steffensen considers building the vessel. A new vacuum system to load living fish is considered to reduce injury on the living fish. The fish to be kept alive will be sorted out and dropped into the center hold that is filled with water.

The unloading of the living fish is planned to be executed by pressurization of the hold. A new electrical anaesthetizing system is planned to be used on the fish to be slaughtered before cutting and bleeding out in water. The slaughtered fish will be stored in containers with ice in the starboard and port holds. Contact: Roar Pedersen (Roar.Pedersen@sintef.no).

Introduction of pair seining as means to increase CBA landings for the smaller coastal fleet

In order to increase the landings of live cod for buffer storage and on-growing, as well as to include small vessels (< 15meter) in this fishery, a work started in 2010 using the Canadian pair seining technique as described from the early 1970's. Different ways of shooting ropes were tested; both from one or both boats, with the last version being the most promising, and most suitable for the smallest boats. Hauling of ropes from two boats was controlled by using Simrad PI Geometry system that worked very well with five coils of ropes. This system did also prove efficient to equal uneven length of ropes. A combined bottom seine and purse-seine sounder gave very good information on bottom contact for the gear. A pilot study on using a normal bottom seine for pelagic pair seining for haddock became very interesting, as the fish turned out to be caught by surprise rather than being run over as with trawl. Experiment with pelagic pair seining as well as catch limiting devices for seine net will continue in 2012/2013. Contact: Bjørnar Isaksen (bjoernar.isaksen@imr.no) or Odd-Børre Humborstad (odd-boerre.humborstad@imr.no).

A new 15 m multipurpose coastal fishing vessel with integrated automatic longline hauling system.

The 15 m speed-vessel "Ingvaldson" was built at Seigla Ehf, Iceland, during 2010/2011 and started operating during May 2011. The vessel is designed for longlining, gillnetting and crab potting and it's equipped with an automatic longline hauler unit (ALH system). During a 6 month period we followed the longline fishery, targeting mainly cod and haddock along the grounds 60 to 80 naut. miles outside Northern Norway. Observations during trials at sea were focused at HES issues during fishing operations and catch results when hauling the line through the ALH system. The crew of the vessel are pleased with easier work due to the removal of the gaff during

hauling and acknowledge improved safety at sea as the vessel can be sealed during rough weather. Observations of lost fish during hauling showed smaller numbers than during conventional methods and were in the range of measurements recorded during trials on board the 51 m “Loran”, i.e. the pilot vessel for the integrated ALH system. Contact: Roger B. Larsen (roger.larsen@uit.no).

Operational and gear related effects on the quality of cod caught by gillnets

Two coastal vessels (12 and 15 m) were used to gather data from gillnet landings of prespawning cod. During these trials we studied the effect on quality (graded by professional crew on the fish plant) as a function of soaking time and type of twines in the gillnets. It was clearly demonstrated that quality improved with reduced soaking time. In most cases fish were alive when the nets were retrieved after 8 or less hours. A similar effect was found when the nets were changed from mono- to multi-monofilament twines. Despite fish stayed longer alive in the multimonetwines, soaking time still seems to be the most crucial parameter for the quality of gillnet-caught cod during winter. Contact: Roger B. Larsen (roger.larsen@uit.no).

15.10 Spain (Basque region)

15.10.1 AZTI Tecnalia (Technological Institute for Fisheries and Food; www.azti.es) by the Marine and Fishing Gear Technology Research Area.

MANTOIL: Development of a Condition Based Maintenance System for diesel engines to improve energy efficiency in fishing boats.

The running parameters of a main engine of a fishing boat are being monitored, including: power output, fuel consumption, exhaust gas temperature, suction air temperature, turbocharger pressure and some other minor measurements. Data are analysed with Advanced Neural Networks in order to detect dependencies of fuel consumption with different engine running parameters. Maintenance patterns and operations are analysed to detect efficiency losses in main engine.

AURREZLE: Evaluation of fuel saving devices and fuel additives in energy efficiency of diesel engines.

Two different fuel saving devices, fuel polarizer and hydrogen generator, are being tested in test bench conditions and normal operation conditions on board a ship in order to evaluate the fuel consumption improvements in diesel engines.

Three different additives are being tested in test bench conditions and normal operation conditions on board a ship in order to evaluate the fuel consumption improvements in diesel engines.

PYROPLANT: Evaluation of Combustion Performance of fuel obtained from pyrolysis of plastic residues

Combustion performance of fuel obtained from the pyrolysis of residual plastics is being evaluated in test bench conditions. The tests are carried out in small monocylindrical engine (5 kW @ 3000 rpm) and in genset (50 kW @ 1500 rpm). The evaluation consists of analysis of the combustion and the emissions from the fuel oil obtained in the pyrolysis process.

ITSASOST: Evaluation of commercial absorption machine for its employment on board a ship

A commercial absorption machine has been installed in a moving platform in order to check the performance of the equipment and analyse possibilities of employment on board a ship. Performance analysis has been carried out and possible modifications analysed to evaluate the possibility of applying the modifications to the equipment.

Reduction of the discards by mean of selective devices in the “baka” single bottom trawl

In this project we will try to reduce the discard in bottom trawlers operating in ICES VIIIa,b,d by mean of selective devices. In the first steps of this project an underwater video camera was set in different parts of the trawl to study the behaviour of different species of fish and the escapement through the square mesh panel. During 2009 one cruise was carried out and no cruise could be done in 2010 due to a reduction in funds. During 2011 two cruises were carried out with the main goal of determining the selective parameters of the system composed by 70 mm codend and 100 mm square mesh panel. This panel is mandatory to use 70 mm codend otherwise 100 mm codend should be used.

Quantification of the discards and improvement of the selectivity in the artisanal fisheries.

In this project starting in 2009 a characterization and quantification of the discards in the different gillnetting artisanal métiers, has been carried out in order to identify the ones with the higher discard rates. The discard has been characterized (species involved, reason for discard and discard rate by fishing métier). Following an analysis of the possible methods to reduce the bycatch of the more frequent discarded species will be done, paying special attention to the operational factors in the fishery. In fishing trials the selectivity for red mullet with gillnets (47–50–53 mm) has been tested.

Identification of the technological creep since 1950 in some of the most traditional fisheries for the Basque fishers.

In this project, retired skippers were interviewed in order to identify the technological creep in the fisheries they had been involved. With that purpose 3 fisheries were selected, anchovy with purse seining, tuna with pole and lines, tuna with trolling lines and tuna freezers with purse seining in tropical waters. For each one of the mentioned fisheries all the technological improvements introduced in the fishery have been identified and characterized. Following, a description or quantification of the importance of each of the technological changes, in terms of increase of the catches, will be done. In addition information about the evolution of these fisheries has been collected in terms of when was introduced and where from it comes.

Feasibility of changing a boat from stern trawler to Danish seiner.

The high prices for the fuel are leading trawl fleet to a difficult situation. The profitability of this fishing gear in the actual context (high fuel prices and low fish prices) is very low. Some vessel owners are trying to find a solution to this. One of the best alternatives of diversification for trawlers seems to be the Danish seining. In this project, we will study the feasibility of changing a boat from stern trawler to Danish seiner in both, technic and economic aspects.

ATEAK: Reducing bottom impact with off bottom otter boards for the harvesting of demersal fish species

The purpose of this project is to improve the sustainability of the bottom-trawl fleet (OTB) through the adoption of an alternative fishing gear that greatly reduce the impact of groundgear on the seabed. Preliminary results also show improvement of energy efficiency (17%) and safety on board.

ECOFAD: Study of sustainability standards and application of improved technology for obtaining an eco-certification for freezer tuna purse-seiners

The purpose of the project in its technological part is to develop an alternative fishing aggregating device (FAD) that reduces bycatch of sea turtles and sharks. The alternative FAD is also almost entirely biodegradable. The third prototype is being deployed in the Atlantic Ocean (April-July 2012). Tracking and biomass monitoring of the FAD is being carried out by means of buoys provided with echosounder.

NETMO: Study of the behaviour of fish in the tropical tuna fishery to reduce the capture of non-target species

A research cruise (35 days) will be carried out in the Atlantic Ocean using a commercial tuna purse-seiner to test different measures that could reduce bycatch in this fishery. The research activities will include: a) Vertical behaviour of different species around FADs in the area, a) FAD examination (recording of sounds, tagging, underwater observations, etc.) c) Pre-estimate of catch and bycatch, d) Behaviour of fish at FADs (vertical behaviour of different species around FADs in the area), e) Double FADs, f) Behaviour of fish in the net (natural and stimulated behaviour), g) Performance of the purse-seine net, h) Attraction of sharks away from the net, i) Best practices for handling sharks on board.

15.11 Scotland

15.11.1 Marine Scotland – Science, Marine Laboratory, Aberdeen

Catch comparison trials of the flip flap netting grid trawl

A pair of catch comparison trials was conducted in the North Sea to compare a standard Nephrops scraper trawl with the Flip Flap netting Grid (FFG) trawl which has been developed by Michael Watt of Gamrie Bay Trawls.

The results show a large and significant decrease in the number of the three main whitefish species retained by FFG gear. The reductions by weight of cod, haddock and whiting are 73, 67 and 82% respectively.

Nephrops catches were very similar for each gear and there is a weak suggestion that fewer monkfish and megrim were retained by the FFG gear.

Further details are contained in Drewery *et al.*, 2012. Marine Scotland Science Report 08/12 or from j.drewery@marlab.ac.uk or r.kynoch@marlab.ac.uk

The drag of three designs of prawn trawls

Experimental trials were carried out in the Moray Firth, Scotland during March 2012 to compare the drag of a standard prawn trawl with (i) a trawl with large mesh netting in the top sheets and (ii) a low headline prawn trawl. Preliminary analysis indicates that the standard gear has the highest drag, followed by the gear with large mesh netting and that the low headline gear had the least drag.

These data will be analysed to see if the fuel savings associated with using the gears of reduced drag will offset any potential losses as a result of any reduction of fishing performance.

Further details can be got from b.oneill@marlab.ac.uk or k.summerbell@marlab.ac.uk

Fish behaviour at the mouth of a trawl gear – the 3T trawl

Further trials with the 3T Trawl (a trawl partitioned into three sections using two vertical panels running from the mouth of the net to three separate codends) were conducted on fishing grounds north of Shetland.

Nine hauls were carried out with up to four video cameras positioned along the headline and near the wing end to provide footage of fish in the mouth of the net. Artificial light sources had to be used as the water depth at the Flugga grounds ranged between 110–130m.

Catch data were obtained for 21 of the 23 fishing tows carried out over the cruise.

The observations of fish behaviour at the mouth of the gear and the catch data will be used to help design a trawl that will reduce the capture of cod but retain megrim and monkfish.

Further details can be got from k.summerbell@marlab.ac.uk or b.oneill@marlab.ac.uk

Benthic Impact and sediment Mobilization by trawl gears

The data from experiments carried out in 2009 to use a Reson 7125 MBES to measure the concentration of sediment were analysed. This work was carried out in conjunction with Dan Parsons and Steve Simmons of Hull University and compared measurements of the concentration of sediment mobilized in the wake measured (i) by divers in the TUV using a LISST 100X and (ii) acoustically, using a Reson 7125.

Further details can be got from b.oneill@marlab.ac.uk

15.12 USA

15.12.1 Massachusetts Division of Marine Fisheries – Conservation Engineering Program

Contact: Michael Pol (mike.pol@state.ma.us), David Chosid and Mark Szymanski

A Network to Redevelop a Sustainable Redfish (*Sebastes fasciatus*) Trawl Fishery in the Gulf of Maine

This project is a collaboration among netmakers, gear researchers and other scientists, fishers, processors and regulators to increase exploitation of a fully rebuilt stock of redfish that was once nearly unfishable due to small numbers. The project consists of multiple components including exploratory fishing, codend selectivity, bycatch reduction, marketing, and outreach. At this point, exploratory fishing is completed showing good ability to target fish with codend mesh smaller than legal size (114 mm). Codend selectivity trials under direction of Pingguo He are planned for July and August 2012.

CEMFIN/GEARNET: Conservation Engineering Marine Fisheries Initiative

This initiative is another collaborative network with the goal of assisting industry transition to output controls by identifying short-term technology transfer and pilot gear projects, based on existing knowledge and experience that could quickly reduce bycatch and avoid weaker stocks. Identified projects include demonstration of the

large-mesh fronted haddock net, drop chain/raised footrope trawls, topless/cutaway trawls, norsel gillnets, acoustic pingers, cod pots, and others. Field efforts are in various stages of completion, with some to continue into 2012. Collaboration with Shelly Tallack and Steve Eayrs of GMRI, Pingguo He of SMAST, and others. www.gearnnet.org

A Low-Cost, Underwater Self-Closing Codend to Limit Unwanted Catch

This innovative codend reduces bycatch by automatically closing itself off from the rest of the trawlnet after catching a preset, adjustable, volume. Using low-cost hardware, the filling codend causes the release of a line that allows the codend to fall back and to cinch shut while allowing other fish in the net to escape. After the prototype construction, testing was conducted on dry land by suspending the codend from a crane and filling a large bag in the bottom of the codend with water; the trigger opened and the codend closed off, allowing us to further refine the design. In field-testing in June-July, 2011, we found good repeated separation of the codend when enough fish were caught; when too little fish were caught, the codend stayed open underwater. Resetting the codend for the next tow took less than approximately three minutes and was not labour intensive. The release of a parachute to increase drag and signal the vessel requires more work. Flume tank testing is planned for June 2012.

Investigation of Haddock and Flounder Behaviour near Standard and Floating Bridles

In collaboration with Pingguo He, underwater video and catch comparison was used to assess the impact of floating bridles made of Dyneema with standard groundgear on a commercial fishing vessel. Preliminary video analysis of behaviour shows little or no contact with the seabed with floating bridles, and a much higher level of disturbance of skates (Rajidae) and other species with traditional groundgear. Effect on targeted haddock catch in paired comparisons was hindered by low catches and vessel breakdown. Analysis and write-up, including the use of computer modelling to correct for camera distortion in behavioural analysis, are underway.

Design and Test of a Squid Trawl with Raised Footrope Rigging and a Grid Device to Reduce Winter Flounder, Scup, and Butterfish Bycatch

A grid was tested in April-May 2011 to reduce bycatch in a Loligo squid trawl fishery in coastal waters. Following flume tank testing of a rigid grid with adjustable spacing, a rigid, adjustable grid was tested in April-May 2011. Preliminary analysis of squid behaviour shows active escape responses at the grid with mantle orientation important to escape likelihood. Catch analysis indicated unacceptable loss of squid. Further work is planned in April-May 2012 concentrating on documenting squid behaviour from the mouth of the trawl to the grid. A collaboration with Pingguo He.

15.12.2 NOAA Fisheries, Northeast Fisheries Science Center, Protected Species Branch, Woods Hole, Massachusetts

Contact: Henry Milliken (Henry.Milliken@noaa.gov)

More info: http://www.nefsc.noaa.gov/read/protsp/PR_gear_research/

Gillnet configurations and their impact on Atlantic sturgeon and marine mammal bycatch in the New Jersey monkfish fishery: year 1

Contract to: D.A. Fox, K. Wark, J.L. Armstrong, L.M. Brown

Monkfish (*Lophius americanus*) support a lucrative fishery primarily centered in the waters of the mid-Atlantic and northeast US. Monkfish are targeted primarily through trawls and sink gillnets. In an attempt to provide resource managers information on the influence of tie-downs employed in the monkfish fishery on Atlantic sturgeon and marine mammal bycatch, we employed two gillnet configurations (control: 12 meshes x 30.5cm stretch mesh with four mesh (1.2 m) tie-downs, experimental: 12 meshes x 30.5cm stretch mesh without tie-downs) in an experiment off northern New Jersey during November and December of 2010. Cooperating monkfish fishermens fished paired replicates of each gillnet configuration totalling 120 hauls in accordance to normal monkfish fishing operations. Atlantic sturgeon bycatch (cpue) did not differ significantly ($p=.1158$) between gillnet configurations, likely due to relatively low statistical power (.1708) in the current study. The experimental nets (without tie-downs) significantly decreased ($p<.0001$) landings of the target species, monkfish and resulted in a number of marine mammal (e.g. common dolphin (*Delphinus delphis*)) mortalities, which were not encountered in tied-down nets. Our findings provide much needed information to managers on the role that net configuration plays in targeted landings and bycatch of Atlantic sturgeon and marine mammals in the sink-gillnet monkfish fishery. Due to the low statistical power, additional control and experimental hauls need be observed in future to provide a confident conclusion.

Gillnet configurations and their impact on Atlantic sturgeon and marine mammal bycatch in the New Jersey monkfish fishery: year 2

Contract to: D.A. Fox, K. Wark, J.L. Armstrong, L.M. Brown

Report just received and not yet reviewed. Preliminary results suggest that a low profile gillnet comprised of 12 inch (0.3 m) mesh that is six meshes high and tied down to 24 inches (0.6 m) reduces the catch of sturgeon when compared to a gillnet that is comprised of 12 inch (0.3 m) mesh that is twelve meshes high and tied down to 48 inches (1.2 m). There was some loss of targeted monkfish, which appears not to be significant, but the fishers involved in the study feel that this may be mitigated by adding two more meshes to the low profile gear. Again, the results are preliminary.

Projects planned for 2012

The NEFSC plans to assess the topless trawl that successfully reduced sea turtle bycatch (see entry below: **Mitigating Sea Turtle Mortality in Demersal Trawl Fisheries in the Northwest Atlantic**) for its effect on the retention of target finfish species in the NW Atlantic. We also expect to test a slight modification to the low profile monkfish gillnet to reduce Atlantic sturgeon. We hope that the addition of two meshes in the low profile gillnet will improve the retention of monkfish.

15.12.3 University of Rhode Island Fisheries Center, Kingston, Rhode Island

Contact: Laura Skrobe (lskrobe@uri.edu), Dr Kathleen Castro, Barbara Somers, Najih Lazar, and Christopher Parkins

Reducing the Capture of Flatfish in Small Mesh Bottom Trawls Using the 30.5 cm (12 in.) Drop Chain Trawl Net Design

A modified fishing net (MFN) was designed using a standard bottom-trawl squid net (SFN) with the addition of 30.5 cm (12 inch) extensions to the headrope and a 30.5 cm (12 inch) drop chain between the sweep and the footrope. This net was laboratory and field tested for its ability to reduce the capture of flatfish. A total of 48 successful comparative paired tows (96 total tows) were completed. After checking for vessel

effects, a paired t-test was used to test for differences between the combined mean weight (catch by species) per tow (in kilograms) of the SFN and MFN. Results show a significant difference between mean weights per tow for summer, winter, yellowtail, fourspot and windowpane flounders. There was no significant difference between mean weights captured by the SFN and MFN for all three potential target species. The findings of this research indicate the 30.5 cm (12 in.) drop chain trawl design has the ability to reduce the capture of flatfish while retaining target species in the small mesh fishery of Southern New England.

Fishery-independent Scup Survey of Eight Hard Bottom Areas in Southern New England Waters

This project is entering its ninth year. It is designed to collect scup from hard bottom sites using unvented fish traps in southern New England (SNE). This survey would be used as a way of supplementing the existing fishery-independent surveys from areas which are not well surveyed by bottom trawls. Commercial vessels perform the fieldwork which is conducted in areas which are un-sampled by current state and federal finfish trawl surveys. A total of 15 fixed sites are sampled from June through October. This project is a collaboration between commercial fishers, URI Fisheries Center, RI Department of Environmental Management Division of Fish and Wildlife, and the Massachusetts Division of Marine Fisheries. In 2010, data on black sea bass were also collected and continued in 2011 and 2012. Analysts from the School for Marine Science & Technology (SMST) have conducted a comprehensive analysis and a peer review workshop was held in 2011 to go over the analysis and discuss terms of reference. As a response to the peer review, a fixed vs. random component was conducted in 2011 and a preliminary analysis was conducted by SMST.

Industry Based Survey on Black Sea Bass Utilizing Ventless Traps

A fishery-independent black sea bass survey of four separate hard bottom sites in Southern New England (SNE) and Mid-Atlantic waters is being conducted in 2012. Unvented black sea bass pots will be fished on each site for five months running from June through October in NE, and April through August in the Mid-Atlantic. Four commercial vessels will conduct the fieldwork in collaboration with University of Rhode Island (URI) Fisheries Center, SMST as well as the Rhode Island Department of Environmental Management (RIDEM) Division of Fish and Wildlife, Massachusetts Division of Marine Fisheries, New Jersey DEP Fish and Wildlife, and Virginia Marine Resources Commission (VMRC). The project is designed to collect black sea bass from four separate hard bottom sites, which are un-sampled by current state and federal finfish bottom-trawl surveys. The length frequency distribution of the catch will be compared statistically to each of the other collection sites, and to finfish trawl data collected by the National Marine Fisheries Service (NMFS) and state agencies. The overall goal of the project is the development of an industry based fishery-independent fixed gear survey of black sea bass in the core range of the stock, resulting in a new index of abundance that can be used to further improve the quality of the stock assessment.

Gillnet Catch Comparison Research Study in the Gambia

A gillnet catch comparison study is being conducted in The Gambia, West Africa, between the net currently used by fishers and a correctly hung net with proper floatation to fish as a vertical wall of webbing. The nets are being fished side by side and sampling will be conducted 2 times a week for one month with a 24 hour soak time identical with current soak time in the gillnet fishery. Analysis will be conducted in

order to determine if there is any difference in catch and selectivity between a properly hung gillnet and the gillnet design that is currently being fished.

15.12.4 University of Rhode Island, Kingston, Rhode Island

Mitigating Sea Turtle Mortality in Demersal Trawl Fisheries in the Northwest Atlantic

Contact: J. DeAlteris, C. Parkins and H. Milliken, URI and NMFS

Turtle Excluder Devices (TEDs) have been the required bycatch reduction technology used to reduce sea turtle mortality in the southeast shrimp bottom-trawl fisheries in the USA for the last 30 years. TEDs have been required in selected mid-Atlantic fin-fish bottom-trawl fisheries for 15 years, but fishers have been concerned that there was a substantial loss of target species. A comparative tow study (n=37 paired tows) conducted in 2007 confirmed a 35% loss of summer flounder, the target species when using a TED. A subsequent effort to design and test an improved TED in 2008–2009 only resulted in a slight improvement in catch retention of the target species (n=41 paired tows). The problems with the original and the improved TED were related to clogging of the sorting grate due to large skates and rays and heavy catch volume. An alternative strategy was considered. Instead of releasing sea turtles after they are captured with a trawl with a TED, a topless trawl was designed that would potentially allow sea turtles to escape from the mouth of the trawl prior to being captured by the trawl. Comparative tows of the initial topless trawl design in 2010 demonstrated that it captured the target species, summer flounder, as well as the traditional trawl (n=41 paired tows). A subsequent paired tow experiment was conducted in 2011 to evaluate the ability of the topless trawl to not capture sea turtles. The initial topless trawl design failed to not capture sea turtles at a rate that would provide sufficient conservation benefit. A modified topless trawl design proved to only catch a single sea turtle while the traditional trawl that was being towed alongside of it captured 25 sea turtles, thus demonstrating the potential conservation benefit of a topless trawl design. Analysis of the fish and crab catch of the modified topless and traditional trawls were similar. Final testing of the catch efficiency of the topless trawl as compared to the traditional trawl for the target species is scheduled for this summer (2012).

15.12.5 Consortium for Wildlife Bycatch Reduction

Members: New England Aquarium, Center for Ocean Engineering, University of New Hampshire, Maine Lobstermen's Association, Duke University Marine Lab, Blue Water Fishermen's Association.

Director: Tim Werner (twerner@neaq.org)

The Consortium for Wildlife Bycatch Reduction is a partnership of fishers, wildlife biologists, and engineers. The Consortium supports collaborative research between scientists and the fishing industry to develop practical fishing techniques that reduce the bycatch of threatened non-target species. Projects supported by the Consortium come under three main categories: (1) Global exchange of bycatch reduction technology; (2) Understanding wildlife interactions in commercial fishing operations; and (3) Research and development of bycatch reduction methods. Some of the Consortium's current projects are described below. Additional details on Consortium projects, including a searchable database of bycatch mitigation techniques, are available at www.bycatch.org.

International Gillnet – Marine Mammal Bycatch Mitigation Workshop

New England Aquarium

Bycatch in coastal gillnet fisheries is a serious threat to many marine mammal populations worldwide. The Consortium for Wildlife Bycatch Reduction held a workshop in October, 2011 to bring together 50 experts on marine mammals and gillnets from around the world. Participants discussed the state-of-the-art in gillnet bycatch mitigation techniques, including acoustic deterrents, non-acoustic gear modifications, time area closures, and gear switching and identified research priorities for the future. A theme section of Endangered Species Research will feature papers from this meeting that evaluate various techniques for reducing marine mammal bycatch in gillnets.

Tests of Various Hook Designs (Circle, Offset, Tuna, and J) and Strengths

University of North Carolina at Wilmington, Duke University

Weak hooks are currently recommended for use by NOAA Fisheries Service in the Gulf of Mexico pelagic longline fishery to reduce bluefin tuna bycatch and mortality, and they are considered a possible bycatch mitigation method for several other species, including pilot and false killer whales. The objective of this project is to provide biological guidance for whale-safe weak hook trials by understanding the thresholds of hook bending capacity of the jaws of these odontocetes. The variation in hook strength within standardized commercially available hooks will be tested to assess whether hooks that are currently available on the market are of consistent enough strength to be used in a mitigation strategy. To test the effect of hook type and strength on the probability of straightening and pulling out of the mouth of a whale, hooks will be embedded in the jaws of heads from stranded carcasses of pilot whales and other large odontocetes. It will be determined whether the size of the whale has an effect on the likelihood that a hook will pull out by comparing results across heads of different sized whales. The results of this work will aid in determining whether there is a threshold in hook strength below which most hooks will straighten and pull out of the jaw of a pilot whale or false killer whale.

Atlantic Shark Bycatch Reduction

NOVA Southeastern University, Florida Atlantic University, New England Aquarium

The goal of this project is to evaluate the potential for a bait mimic device in longline fisheries to reduce elasmobranch bycatch. The bait mimic device is a battery-powered prey simulator that is designed to attract elasmobranchs away from the actual bait. Preliminary behavioural trials were conducted with captive leopard, lemon and bonnethead sharks in an electrically quiet tank environment. For bonnethead and lemon sharks, half of all interactions with the electric capsule resulted in the shark biting the target rather than the bait. In the control experiment, the bait was attacked three times more frequently than the unpowered control capsule. For leopard sharks, over half of all bites were directed at the electrical capsule rather than the bait; however, during the control trial, all bites were directed at the bait. This suggests that the electric capsule provides a stimulus that is attractive to the sharks and diverts them from the bait at a much greater rate than the control treatment. However, sharks showed a decreasing interest in the prey-simulator with repeated trials which may indicate that the 'dummy' target may become less effective with increased exposure. Field trials off California on a pelagic longline vessel targeting swordfish and yellowfin tuna were conducted in summer 2011 to test the design and additional field trials are scheduled for 2012.

Dynamics of Large Whale Entanglements in Fixed Fishing Gear

New England Aquarium, Maine Lobstermen's Association, Provincetown Center for Coastal Studies, Woods Hole Oceanographic Institution

The goals of this project are to identify the characteristics of fishing gear that cause severe and fatal entanglement risk to whales and provide a stronger scientific basis for evaluating the impact of existing proposed and future potential fishing methods to whales. The first part of this project developed criteria and descriptions for defining injury and gear entanglement severity. Nine hundred and seventy right whale entanglement events documented from 1980–2008 were categorized using this criteria. The second part of this project documented fishing gear entanglements of 47 right whales and 43 humpback whales through case studies. The studies included illustrations of the gear on the animal, an analysis of the retrieved gear, life-history information about the whale, injury and entanglement severity, and the fate of the whale. Finally, a variety of analyses are being conducted to evaluate the role of whale age and species on entanglement complexity, the breaking strength of the entangling rope, and fate of the animals.

Assessing Right Whale Entanglement Risk Using Whale Flipper and Interaction Experiments

University of New Hampshire, New England Aquarium

This project examined the characteristics of interactions between vertical pot/trap lines and whale flippers using a full-scale model of a right whale flipper. The impacts of different rope diameters and rope tensions were examined by driving the model flipper, which was attached to a boat, into the vertical lines. Tests indicated that the duration of the entanglement was slightly dependent on the angle of the flipper relative to the longitudinal orientation of the whale and distance from the body. It was hypothesized that taut vertical lines would prevent entanglement, but tests showed the line digging and sawing into the flipper before becoming released. Data from these tests will be used in the computer simulation modelling whale entanglement events described below.

Modelling Whale Entanglement Events

Duke University, Bellequant Engineering, New England Aquarium, University of New Hampshire

In the absence of direct observations of entanglement events involving baleen whales, the goal of this project is to better understand the dynamics of rope entanglements through computer models. A whale entanglement modelling system (WhEMS) is being developed to simulate entanglements between baleen whales and fishing trap gear. Currently, the program has four whale models: three versions of a North Atlantic right whale (closed mouth, open mouth, and closed mouth pregnant) and a closed mouth humpback whale. The trap gear models have been designed based on information collected from Maine lobstermen. The whale and gear models will be able to react to the forces placed upon it by gravity, buoyancy, current, tension, and contact with other objects. Users can simulate whale entanglements to help understand the dynamics of entanglements and allow identification of gear types and specifications that pose the greatest risk for producing severe entanglements.

15.12.6 University of Massachusetts Dartmouth, School for Marine Science and Technology (SMAST), New Bedford, MA

Discard Mortality Estimation of Flatfish

Contact: Adam Barkley (u_abarkley@umassd.edu)

Yellowtail flounder

Reflex Action Mortality Predictors (RAMP) provide a tool to address the estimation of discard mortality using direct observations aboard fishing vessels. Reflex impairment of yellowtail flounder (*Limanda ferruginea*) was examined and was found to have a significant positive relationship between reflex impairment and mortality using a suite of seven reflexes. Reflex Action Mortality Predictors were tested aboard commercial otter trawl and scallop dredge vessels. These trips resulted in 1778 yellowtail flounder tested aboard scallop vessels and 368 yellowtail flounder tested aboard otter trawl vessels. The estimate of discard mortality from the scallop dredge vessels is 85% with upper and lower confidence intervals ranging 72–93%, and 79.5% from otter trawl vessels with confidence intervals ranging from 65.5–88.5%. The estimates for scallop dredge vessels and otter trawl vessels were similar so a pooled estimate covering both gear types was evaluated indicated a discard mortality rate of 84.5% with confidence intervals ranging from 71–92.5%. These estimates cover all seasons and multiple gear types and are valid estimates of discard mortality rate for stock assessments and fishery management.

Winter flounder

Estimating the mortality rate of winter flounder (*Pseudopleuronectes americanus*) that are discarded is increasingly important for stock assessment and fishery management because recent regulations increased discarding. A controlled experimental trawl was used to test seven reflex actions from stressed and unstressed winter flounder. This suite of reflexes make up the Reflex Action Mortality Predictors (RAMP). Tow-time and air exposure were tested to identify their effect on mortality. Mortality was significantly related to reflex impairment, but neither air exposure nor tow-time significantly affected the mortality of winter flounder. Reflex impairment observations were made aboard commercial trawl and scallop dredge vessels and demonstrated a discard mortality range of 10% to 44%, which is significantly less than the 50% currently assumed for stock assessment and catch monitoring. The reflex impairment-mortality relationship will enable more representative estimation of discard mortality aboard commercial fishing vessels for various gear types and all seasons.

Reducing seal depredation in the Nantucket Sound weir fishery

Contact: Owen C. Nichols (onichols@umassd.edu; SMAST/ Provincetown Center for Coastal Studies), Ernie Eldredge (Chatham Fisheries/Monomoy Trap Co.), Steve Cadrin (SMAST)

Gray seals (*Halichoerus grypus*) have been observed feeding on fish weir catches in Nantucket Sound (Massachusetts, northeast USA). Partially consumed longfin inshore squid (*Loligo pealeii*) and finfish in the nets recorded in logbooks are attributable to seal depredation, and seal depredation behaviour in weirs has been observed using Dual-frequency Identification Sonar (DIDSON) throughout 24-hour periods, most frequently at night. Observations of seal and target species behaviour indicated that seal presence likely affected the efficiency of the weir, disrupting the passage of schooling squid and finfish into the catch chamber. The above data are being used to inform the design of gear modifications to reduce depredation by excluding seals while maintaining catches of squid and fish. Preliminary trials carried out in spring 2011 demonstrated that an excluder grid kept seals out without entanglement while allowing squid and finfish to enter the catch chamber. Development of the excluder design will continue in 2012.

Trawl gear modifications to reduce flatfish bycatch and discards

Contact: Sally Roman (sroman@umassd.edu)

Testing of a modified otter trawl groundgear to reduce the catch of juvenile American plaice Sea trials were completed over two seven day trips in March of 2011 to test a groundgear modified with “escape” windows to assess if the catch of undersized American plaice could be reduced while retaining commercial catches of legal sized fish. The experimental groundgear, designed by Reidar’s Manufacturing Inc., is constructed of rock-hopper discs, cookie discs and has rubber risers along the entire length of the trawl that create space between the net and the groundgear to promote escapement early in the capture process. On the first trip, the dimensions of the windows were 40 cm by 18 cm, which resulted in a reduction in the catch of legal sized American plaice. The width of the window was decreased to 20 cm for the second trip. Data analysis on the effectiveness of a modified groundgear to reduce the catch of sublegal American plaice is being completed.

Test of a modified groundfish trawl to reduce the catch of Southern New England winter flounder

The proof-of-concept project funded by the Commercial Fisheries Research Foundation was recently completed over three days of comparative sea trials in April, 2011. A large mesh panel of 1.9 m diamond mesh replaced traditional 165 mm diamond mesh in the center of the belly 76 cm behind the fishing line. A modified groundgear was also tested, which consisted of 25 cm rock-hopper discs and 15 cm rubber discs with rubber risers along the length of the trawl. The risers create “escape” windows of 46 cm x 30 cm between the fishing line and the groundgear. The design allowed too many cod to escape from the window and large mesh panel. The second phase of comparative sea trials with modified groundgear escape windows was completed in April, 2012. Only the modified groundgear was tested; the large mesh panel was removed. The results were much more encouraging. Further tests are being considered on the design.

Bycatch Avoidance in the Sea Scallop Fishery

Contact: Cate O’Keefe (cokeefe@umassd.edu)

Bycatch of yellowtail flounder in the US sea scallop fishery is a constraint to achieving optimum yield of scallops. Since 1999, the rotational area scallop fisheries on Georges Bank have been subject to total allowable catches for yellowtail flounder bycatch, which can force early closures of these scallop fisheries. To address this constraint, we collaborated with the scallop fishing industry to initiate a bycatch avoidance program. We designed a system to collect information on incidental catch that expands the use of existing Vessel Monitoring Service technology and relies upon the fishing fleet to provide data. Vessels supply us with real-time communications about incidental catch rates during fishing activities. In turn, we compile the information for the fleet and send it back to active vessels. While providing spatially- and temporally-specific data on catch rates of non-target species, the fishing fleet gains valuable information about distribution of these species in order to avoid bycatch “hot spots”. The program has been utilized for the Georges Bank rotational fisheries since 2010, and has led to a significant change in fishing behaviour. Bycatch of yellowtail flounder has been reduced by approximately 70% in these years.

Fish Behaviour and Conservation Engineering

Contact: Pingguo He (phe@umassd.edu)

Bycatch reduction in northern shrimp trawls

Analysis on the shrimp trawl size/species sorting grid experiment carried out in 2009 in Gulf of Maine has been completed. Both 9 mm and 11 mm size sorting grids reduced small shrimps compared with a regular Nordmøre grid without a size-sorting grid. A modified Nordmøre grid with netting around the grid removed (called Rope grid) reduced catch of finfish by 42–48%. A combination grid of size sorting and finfish reduction showed good results in reducing small shrimps and finfish. A new experiment replacing regular wire bridles with synthetic bridle has been completed. The use of “floating” polypropylene bridles keep the bridle off the seabed thus reducing herding of bottom-dwelling flatfish. A 20% reduction has been observed for important flounder species without reduction in Northern shrimp catch.

Species separation in groundfish trawls

A project testing the rope separator haddock on offshore grounds (Georges Bank) with a larger vessel >80' has been funded with part of sea trials completed in May 2011 and the remaining to be completed in April/May 2012. This trawl is a larger version of the rope separator trawl tested in inshore Gulf of Maine in 2006 when very positive results in reducing cod and flounders were realized in the new haddock trawl. The offshore trials resulted in reduction of flounder catch by 95%, skates catch by 84%, and cod catch by 87%. Haddock catch was reduced by 17%, but was not statistically significant after 24 pairs of tows. Another project (collaborating with Mass. Div. Mar. Fish.) to further understand behaviour of flounders and haddock, and to reduce flounder catch when targeting haddock was completed with sea trials concentrated on underwater filming of fish near bridles. The project intended to implement floating bridles in haddock trawls to reduce bottom-dwelling flatfish. Video and data are being analysed.

Silver hake trawl research

Small mesh silver hake trawls may catch other groundfish and spiny dogfish, as well as other controlled species. One silver hake trawl design incorporating large meshes in the front end of the trawl to reduce spiny dogfish is being tested in Southern New England waters. Another silver hake trawl incorporating belly windows to reduce flounders is being tested in Gulf of Maine.

Squid Trawl

Squid trawls in southern New England also catch other species such as butterfly, black sea bass, scup, and winter flounder. To reduce these species, a grid was designed and tested in flume tank. Sea trials with the new grid started in May 2011, and will be continuing in April/may 2012. The preliminary design includes the raised footrope design and a sorting grid. Video recording from 2011 trials are being analysed. Collaboration with Mass. Div. Mar. Fish.

Redfish codend selectivity

In collaboration with Massachusetts Division of Marine Fisheries, we have started a redfish codend trawl selectivity project to compare selectivity properties of five codends: 4.5, 5.0, 5.5, 6.0, and 6.5" diamond mesh sizes on board one or two commercial fishing vessels. Sea trials will be carried out in July/August 2012.

Elasmobranchs electro-magneto-reception and their conservation

Craig O'Connell, a PhD candidate in the group, is carrying out several projects investigating electro-magneto-reception of elasmobranchs and its application in hook and

line fisheries to reduce bycatch of spiny dogfish and in beach nets to reduce mortality of large predatory sharks.

Scallop dredge

A new project has been funded to re-design the New Bedford-style scallop dredge to reduce yellowtail flounder bycatch and to reduce fuel costs and seabed impact during dredging. Design work has started, with sea trials planned in summer/fall 2012.

New FBACE website

The Fish Behavior and Conservation Engineering group (FBACE group) of the School for Marine Science and technology of University of Massachusetts Dartmouth has just launched a new website (www.smast.umassd.edu/fish). We plan to update the site regularly with project activities, photos, reports and publications.

15.12.7 NOAA Fisheries, Southeast Fisheries Science Center

More info: http://www.nmfs.noaa.gov/by_catch/bycatch_BREP.htm

Turtle Excluder Device Technology: Evaluations and Fisher Outreach

Net reels of various sizes and configurations are used on vessels operating in the flynet fishery, posing significant structural and operational problems when it comes to traditional TED designs that are constructed of rigid frames. The industry requested the development of flexible prototypes that can be easily stored on net reels but are durable enough to withstand harsh commercial fishing conditions. Two prototypes were developed by NMFS SEFSC Fisheries Methods and Equipment Specialists. The TEDs were constructed almost entirely of cable, which provides for easy storage. Commercial trials were conducted with one of the designs to examine potential target catch loss and usability of the gear during the 2010–2011 season. Results of the trials were positive with catches of up to 90,000 lbs recorded with no structural damage to the TED observed. Observations of gear handling indicated that the cable TED design operated virtually hands-free. Both designs were tested for sea turtle exclusion using the NMFS small turtle testing protocol conducted in Panama City, Florida in June 2011. One design passed the certification test, while the other excluded all turtles introduced to the TED during a cursory trial.

Shrimp Trawl Bycatch Reduction Technology

Research conducted in cooperation with the Instituto Nacional de Pesca, Mexico (INP Mexico) involved a series of evaluations of commercial shrimp trawling gear. The new trawl design incorporated a raised footrope that purportedly reduced the bycatch of finfish as compared to standard trawl gear. A total of 12 successful tows were completed comparing a 50-ft. RS-INP-MEX trawl to a 50-ft. Scorpion trawl, a typical southeastern United States design. A combination of gear problems and poor shrimp-ing conditions as well as rough weather resulted in a small number of completed tows. The RS-IMP-MEX trawl demonstrated 40.77% reduction in total catch ($p=0.002$) and a 62.9% reduction in total shrimp ($p=0.002$) as compared to the Scorpion trawl, which were statistically significant. Shrimp reduction for white and brown shrimp was 52.8% and 71.6%, respectively, which were also significant. The estimated reduction of croaker (14.3%) was the only bycatch to show a statistically significant reduction with the RS-INP-MEX trawl. The ratios of fish to shrimp for the Scorpion and RS-INP-MEX trawl are 3.7 to 1 and 7.2 to 1 respectively. The difference in catch rate between the trawls may be attributed to several factors, first of which is the door weight used with the Mexican design. In the previous evaluation, NOAA divers observed

that the doors of the RS-INP-MEX periodically lose contact with the bottom while towing and sometimes ride just above the bottom. The second factor that likely influences the difference in catch rates is the difference in the spread ratio between the trawl designs. Continued collaboration with INP Mexico in this project is anticipated in 2012, during which catch comparisons between the RS-INP-MEX trawl and the Scorpion trawl may be conducted in the Gulf of California.

Reducing Bycatch in the Penaeid Shrimp Fishery Utilizing TEDs with Two-Inch Bar Spacing

In 2011, this project focused on further assessing the efficacy of 2-inch TEDs in reducing bycatch. In an effort to improve shrimp retention with the 2-inch TED, the NMFS Southeast Fisheries Science Center (SEFSC) will conduct catch comparisons between a 4-inch TED and a 2-inch "staggered bar" TED. The 2-inch staggered bar TED features alternating offset deflector bars designed to reduce the deflection of shrimp out of the TED opening. A commercial shrimp trawler has been contracted to perform this work. However, due to a delay in receiving funds in 2011, testing of the staggered bar 2-inch TED is scheduled to begin in early 2012.

Green-Stick Gear Bycatch and Bycatch Mortality Characterization in the Northern Gulf of Mexico Atlantic Tuna Fishery

NMFS is partnering with the Louisiana Department of Wildlife and Fisheries to conduct this study through a contract beginning in September 2011 and continuing through September 2013. The study will characterize the catch and bycatch of green-stick fishing gear when used to target tunas in the northern GOM. A general comparison of species caught and/or retained with green-stick gear will be made against pelagic longline (PLL) gear using summaries of NMFS PLL logbook/observer data. This study is designed to collect data and report on features that contribute to the gear's success (or lack thereof) in catching target tuna species, incidentally kept species, and bycatch. The characteristics of areas where green-stick gear is used successfully for Atlantic tunas will be described, and information will be gathered on the operational requirements of green-stick gear such as fuel consumption, size of vessel, size of crew, and cost of gear.

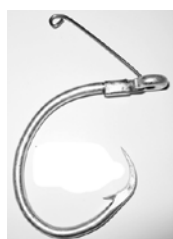
Skimmer Trawl TED Testing in North Carolina (NC) Inshore Waters

The 2011 NC skimmer trawl TED research was successful in identifying various TED configurations that could be used in commercial operations in NC. This technology can also be expanded to other regions in the southeastern Atlantic and Gulf of Mexico where commercial skimmer trawling occurs. Combined with the 2008 – 2010 studies, it appears that TEDs can function effectively in skimmer trawl operations with a relatively minimal (~5%) shrimp loss compared to nets without TEDs installed. However, due to different vessel size, varying water depths, seasonal debris in the water and inconsistent shrimp concentrations, it remains critical for the SEFSC and the commercial skimmer trawl industry to work collectively to develop the optimal TED configuration for each region. During the course of these studies, commercial industry participants and representatives expressed concerns about the use of TEDs in skimmer operations. These included the potential increased drag associated with the use of TEDs, the increased weight, and the relative size of the standard mid-size TED installed in the small skimmer nets. To address this concern a smaller prototype "D-shaped" TED was constructed and slated to be tested in Louisiana skimmer operations by the end of 2012. This TED is 33" x 33" and is constructed of ½" aluminum rod. The decreased size and the D-shape may allow the TED to function more effec-

tively by reducing potential drag and allowing the flat part of the D frame to tow more efficiently in these shallow-water operations.

Examining the Efficacy of Modified Circle Hooks in Reducing the Bycatch of Undersized Lutjanid and Serranid Fish

To examine the potential for reduction of post-release mortality of undersized snapper and groupers caught with circle hooks, the NMFS Southeast Fisheries Science Center (SEFSC) is testing the efficacy of modified circle hooks (in further reducing incidences of gut hooking. The modified circle hook (AP) incorporates a 40-mm wire extension from the hook's eye, thereby increasing the diameter of the hook while negligibly impacting its effective size and weight.



As of the end of 2011, 1,286 fish had been captured, representing 21 genera and at least 27 species. Black sea bass, red snapper, and vermillion snapper dominated the catch, constituting 48.5, 24.0 and 9.5% of landings, respectively. There was no evidence of size-related selectivity (e.g. Kolmogorov–Smirnov test statistic = 0.75, $p = 0.62$ for black sea bass), or reduced efficiency (50.04% captured with circle hooks and 49.96% captured on AP circle hooks for all fish collected) between the two hook types, regardless of species (Figures 9–10). Of the fish that were captured, 97% were lip hooked regardless of hook type. When comparing hooking location by hook type, over 95% of all fish captured were hooked in the jaw; however, 98.75% of fish captured on appendaged hooks were hooked in the jaw, compared to 95.79% of fish captured on circle hooks. Of the 17 fish hooked in the throat or alimentary canal, only one of these occurrences was on an appendaged hook. Data will continue to be collected through spring 2012, with efforts focusing on increasing sample sizes of other recreationally important species such as vermillion snapper.

Commercial Longline Sea Turtle Mitigation

New sea turtle mitigation techniques for the bottom-longline reef-fish fishery were trialed in 2010. This study aimed to characterize the species-specific relationships between catch rates and soak times for target and bycatch species in the bottom-longline reef-fish fishery as a means to promote shorter soak times and reduce sea turtle mortality in the fishery. The SEFSC hopes to acquire additional funding to continue the study in 2012 to further evaluate the seasonal effect and bait type on capture times of target and bycatch species.

Seabird Bycatch in the Western North Atlantic Fisheries

The analysis involved the development of two generalized linear models to examine the effects of hook type (J hooks and circle hooks) and hook size (8/0 and 9/0 J hooks, and 16/0 and 18/0 circle hooks) on (1) the probability of catching one or more seabirds on a set, and (2) the positive catch rate (i.e. number of seabirds per 1,000 hooks in a longline set with seabirds caught). This analysis was confined to the three areas of the pelagic longline fishery where most of the seabirds are caught. This increased almost fourfold the proportion of observed seabird sets having seabird bycatch, which was intended to reduce any possible negative influence of rarity on the analysis. The paired models (delta approach) showed that both hook type and hook size significantly influenced seabird bycatch in the US Atlantic pelagic longline fishery. Compared to hook size, hook type played a lesser role in the probability of catching a seabird but played a more important role on the positive catch rate. Use of the 8/0 J hook led to the highest probability of catching a seabird and the highest positive

catch rate. Results suggest that use of the circle hook could significantly reduce seabird bycatch in the US Atlantic pelagic longline fishery, although its effectiveness might be unrecognized because of other influences on seabird bycatch, such as location, season, target species, and associated fishing tactics.

Evaluation of Weaker Circle Hooks to Release Bluefin Tuna in the Yellowfin Tuna Longline Fishery

Research was conducted from 2008 to 2010 by the Engineering and Harvesting Branch of the NMFS Southeast Fisheries Science Center (SEFSC), Mississippi Laboratories, to evaluate the efficacy of a new 16/0 “weak” circle hook design in reducing the bycatch of bluefin tuna in the Gulf of Mexico yellowfin tuna fishery. Six commercial vessels completed 311 pelagic longline sets. Experimental hooks and standard 16/0 circle hooks were alternated on the longline with a total of 198,606 hooks set. A total of 33 bluefin were caught during the experiment, of which 10 were caught on the experimental hook (56.5% reduction). The difference in bluefin catch was statistically significant. Vessels landed a total of 2,065 yellowfin tuna. The difference in the yellowfin catch rate for standard and experimental hooks was not significant. The SEFSC used 2011 funding to produce and distribute weak hooks for outreach efforts to the fishing industry. The SEFSC also used 2011 funds to construct hook inspection gauges and train law enforcement agencies.

Future work

- Turtle bycatch reduction in the Gulf of Mexico bottom longline fishery (2012–2017)
- Development of fishing methods that mitigate the effects of barotrauma for recreationally caught reef fish (2012–2017)
- Seabird bycatch reduction through enhanced observer coverage to assess potential protected species interactions with fisheries in the Atlantic (2012–2017)
- Turtle bycatch reduction in non-shrimp trawl fisheries (Atlantic flynet fishery, Atlantic whelk trawl fishery, Gulf butterfish fishery (2012–2017)
- Turtle excluder device and bycatch reduction device refinement in shrimp trawl fishery (2012–2017)
- Turtle bycatch reduction in various Atlantic and Gulf of Mexico gillnet fisheries (2012–2017)

15.12.8 NOAA Fisheries, Southwest Region and Southwest Fisheries Science Center, La Jolla, California

More info: http://www.nmfs.noaa.gov/by_catch/bycatch_BREP.htm

Ability of Southern California Deep water Rockfish to Survive Barotrauma Following in-situ Recompression

The goal of this study is to determine the survival rate of deep water rockfish species captured from depths greater than 150 m and subsequently recompressed using weighted cages. Researchers at the NMFS Southwest Fisheries Science Center (SWFSC) tagged four different species of rockfish captured from 150 m to 180 m depths off the coast of Southern California. Rockfish were externally tagged with V9AP accelerometer pressure transmitter tags from Vemco. Species included sunset rockfish *S. crocotulus*, bocaccio *S. paucispinis*, starry rockfish *S. constellatus*, and bank rockfish *S. rufus*. Tag life is 122 days. Immediately after the tags were attached, rock-

fish were recompressed to depths between 40 m to 50 m using a weighted cage. It was determined that rockfish captured from depths greater than 150 m needed to be recompressed to a minimum depth of 45 m. The release cage used was equipped with a video camera and a pneumatic opening door that could be controlled from the boat. With this "cage cam," the SWFSC was able to monitor rockfish as they were recompressed and determine the depth needed for recompression. Temporary moorings attached to VR2W acoustic receivers were deployed in the vicinity of the fishing/tagging site in order to monitor the tagged fish. The receivers will be deployed for up to four months in order to monitor for potential delayed mortality.

Additionally, a subset of rockfish was collected for an analysis of internal injury and long-term survival potential. Rockfish from the most commonly encountered species were dissected to evaluate internal injury as a result of barotrauma (i.e. swimbladder rupture, haemorrhaging), and heart, head, kidney, and rete mirabile samples were removed for further histological examination. On survey trips in 2012, researchers will recompress ~15–30 fish in on-board recompression chambers and then slowly decompress them under controlled conditions. Following decompression, these fish will be maintained and monitored in the SWFSC Experimental Aquarium for two months where they will be non-lethally sampled for blood from a caudal venipuncture at two time points, once rockfish are brought to surface pressure and at the end of the two month observation period. The SWFSC will extract total ribonucleic acid (RNA) from the red and white blood cells and measure the expression of immune genes that respond to barotrauma. This will be another valuable indicator of recovery potential and overall health.

Determining Post-Release Survivorship using Alternative Angling Techniques in the Recreational Fishery for Common Thresher Sharks

We quantified hooking mortality rates associated with traditional mouth-hooking techniques in the southern California recreational fishery. Survivorship was determined using pop-off satellite archival tags (PSATs) deployed on subadult and adult common thresher sharks captured using standardized techniques. All of the trailing gear PSATs used in the 2010 project and five of the mouth hooked PSATs used for this project have been deployed on common thresher sharks captured using fishery standard techniques. For the trailing gear study in 2010, five of the sharks died within 36 hours of capture, two survived, and one remains at liberty. For the mouth-hooked individuals, four of the five tagged sharks survived the acute effects of capture, and the NMFS Southwest Regional Office (SWR) has not yet received the data for the remaining shark. The final tag deployments are slated for spring 2012. A multi-media outreach campaign commenced filming in mid-November 2011, when the NOAA Ocean Media Center sent out a film crew and at-sea field activities were recorded. Additional footage will be filmed in spring 2012, at which time final editing and production of a DVD will take place.

Pinniped Deterrence in Recreational and Commercial Fisheries

This project's objective was to using a smaller-mesh extension or "protection panel" to reduce or prevent pinniped depredation on halibut trawl gear, primarily from harbour seals. Using a smaller-mesh extension might prevent pinnipeds from reaching through the net with their claws and mouths in an attempt to remove or damage fish from this area of the net. We compared catch performance and depredation rate of the halibut trawlnet using a 3-inch mesh size modification to a 5 1/2-inch mesh size trawlnet extension normally used in the fishery. Additionally, an underwater video camera system was used to document the behavioural response of pinnipeds during these experiments. More halibut was caught using the small-mesh extension, although catch was low overall. There was a significant increase in the bycatch of small fish that did not affect the total weight of catch. There were inconclusive results on the numbers of fish observed damaged. There also were observations of fish being pulled out of net by pinnipeds during haulback. Based on these results, a new design to minimize the bycatch of small fish is under development and will be evaluated in 2012. Instead of including the small-mesh extension directly in front of the codend in the trawlnet, a small mesh "protective tube" will be constructed to surround the normal extension and codend in a way that will allow the net to sort out small fish as usual while providing an improved barrier for pinnipeds attempting to depredate during fishing operations.

Future work

- Rockfish mortality reduction through the use of recompression cages and devices (2012–2013)
- Shark bycatch and bycatch mortality reduction in drift gillnet and pelagic longline fisheries (2012–2017)
- Seabird bycatch reduction through enhanced collection of seabird distribution and abundance data on cetacean and ecosystem assessment cruises, action at international regional fishery management organizations, and information and outreach to fishery participants (2012–2017)
- Green sturgeon bycatch and mortality reduction in hook and line, gillnet, and trawl fisheries (2012–017)
- Reduction in whale entanglements from fixed-gear fisheries along the US west coast (2012–2017)
- Pinniped depredation reduction in commercial and recreational fisheries (2012–2017)
- Development and use of genetic stock identification information in fisheries management to avoid weak or ESA-listed salmon stocks in the ocean salmon fishery (2012–2017)

15.12.9 Oregon Department of Fish and Wildlife, Marine Resources Program, Newport, Oregon

Contact: Bob Hannah (bob.w.hannah@state.or.us), Steve Jones, Polly Rankin, Matthew Blume

Evaluating the behavioural impairment of fish escaping a shrimp trawl via a rigid-grate Bycatch Reduction Device

The behaviour of roundfish excluded from an ocean shrimp trawl with a deflecting grid was studied using high-definition underwater video. The study objective was to evaluate the condition of escaping eulachon, a threatened species. Observed behav-

aviours were quantified in relation to a proposed model of an ideal trawl escapement based on an actively swimming fish avoiding contact with the grid. We assumed that a roundfish in excellent condition would, 1) maintain distance from the grid, 2) avoid physical contact with the grid, 3) maintain a forward swimming orientation, and 4) maintain an upright vertical orientation. Large eulachon, came closest to our proposed model of avoidance-based escapement, indicating less behavioural impairment than the other species encountered. Almost 80% of the large eulachon maintained an upright vertical orientation throughout their escape and exited the trawl in a forward-swimming orientation. Large eulachon maintained distance from the deflecting grid better than the other species encountered ($P < 0.001$) and typically showed only minimal contact with it (63%). Only about 20–30% of the large eulachon showed behaviours indicating fatigue, such as lying on or sliding along the grid. In contrast, both adult and juvenile Pacific hake frequently showed signs of fatigue, including sliding along or lying on the grid, exiting the trawl in physical contact with the grid or failing to maintain an upright vertical orientation. Lingcod and juvenile rockfish were intermediate in their escape behaviour between Pacific hake and large eulachon.

Evaluating the effect on demersal fish bycatch from removing the central one-third of the groundline in an ocean shrimp trawl

This was a follow-up experiment to 2011 research investigating the effect on shrimp trawl bycatch from removing the central one third of the trawl groundline, which reduced eulachon bycatch by 33.9% but also reduced the catch of ocean shrimp (weight) by 22.2%. In 2011, we again removed the central third of the groundline, but reduced fishing line height in that trawl to help reduce the loss of shrimp. Shrimp loss was reduced to 14%, however, eulachon exclusion was also reduced to 12%, suggesting that fishing line height is also an important determinant of eulachon entrapment.

Future Work:

- Cage-based estimates of discard mortality (post-recompression) of Pacific rockfish in the recreational hook and line fishery – canary and yelloweye rockfish out to greater depths (60–120 m).
- Large acoustic telemetry study of yelloweye rockfish movements and home range in relation to Marine Protected Area size and boundaries.
- Further tests of footrope changes to minimize demersal fish bycatch – we will test a 6 foot “window” at the center of the groundline to try to utilize the optomotor response of fish to get differential exclusion of fish (relative to shrimp).
- Field tests of a newly developed video lander for deep water high-relief rocky reefs – we will upgrade our lander to high-definition this year and also compare visual census efficiency with and without bait as an attractant for yelloweye rockfish.

15.12.10 NOAA Fisheries, Northwest Fisheries Science Center, Seattle, Washington

More info: http://www.nmfs.noaa.gov/by_catch/bycatch_BREP.htm

Developing, Testing, and Demonstrating Bycatch Reduction Devices in West Coast Trawl Fisheries

We field-tested a bycatch reduction device (BRD) to reduce Chinook salmon and overfished or rebuilding rockfish bycatch in the Pacific hake fishery. This BRD is built

around a four-seam tube of netting that is inserted in the trawl between the last tapered section of the net and the beginning of the intermediate section. The key component of this BRD design consists of two inclined square mesh ramps that are laced inside the BRD tube, creating large escape windows on each side of the net. In previous work, fish behaviour and gear performance were observed using video cameras and artificial light. Although measuring the escapement of Chinook salmon and rockfish was possible using the video cameras, the video cameras were not effective at enumerating the escapement of the more numerous Pacific hake. In 2011, this study focused on incorporating a recapture net in the BRD design to quantify the escapement of Pacific hake and bycatch species under regular fishing activities and under conditions of high-volume catches. During this study, a recapture net was designed and deployed that allowed for quantifying the escapement rates of target and non-target species. Results showed Chinook salmon, yellowtail rockfish, and widow rockfish bycatch was reduced by 21.4%, 8.3%, and 8.3%, respectively. Escapement of Pacific hake, the target species, was 1.2%. Earlier studies conducted on the same BRD employed artificial illumination, whereas escapement rates measured with the recapture net were made in the absence of artificial illumination.

Improving the Selectivity of Bottom Trawls to Reduce Bycatch of Pacific Halibut in the West Coast Groundfish Trawl Fishery

We tested the efficacy of a flexible sorting grate bycatch reduction device (BRD) designed to reduce Pacific halibut bycatch. The BRD is built around a four-seam tube of netting that is inserted between the trawl's intermediate and codend and includes two vertical panels (7.5" mesh) and an exit ramp (5.5" mesh) constructed of AQUAPEX® (cross-linked polyethylene tubing). The flexible grate sorts fish by size as they move toward the codend. The concept of the design is that fish smaller than the sorting grate openings will be retained, whereas fish greater than the sorting grate openings will be excluded from the trawl via the exit ramp. For this project, a recapture net was used to quantify the escapement rates of target and non-target species. Results showed that Pacific halibut bycatch was reduced numerically by 57% and by 62% by weight. A significant difference in mean total length also was noted between Pacific halibut caught in the trawl codend and the recapture net codend; with larger fish occurring in the recapture net. Target species loss ranged from 9% to 22%.

Gained in Translation: Accessing Seabird Bycatch in Russian and Japanese Gillnet Fisheries

This project will be an English translation/summary of the seabird portion of "Accidental bycatch of marine birds and mammals in the salmon gillnet fishery in the northwestern Pacific Ocean" by Yuri Artukhin, V. N. Burkanov, and V. S. Nikulin. This document, which is expected to be finalized in early 2012, will include sections covering: current and historical condition of the salmon fishing industry in the Northwest Pacific Ocean, bycatch of marine birds by the salmon fishing industry in the Northwest Pacific Ocean, and an assessment of losses/ damage to marine bird and mammal populations in the Russian EEZ, including translations and summaries of all data tables and figures.

Future work

- Pacific coast roundfish bycatch reduction by improving performance of already proven bycatch reduction gear types, e.g. selective flatfish trawl to reduce rockfish bycatch in flatfish fishery (2012–2013)

- Endangered Species Act-listed salmon bycatch reduction, as well as rockfish bycatch reduction, through refinement and implementation of flexible sorting grids and other excluders in the Pacific hake fishery (2012–2013)
- Improving the selectivity of bottom trawls to reduce bycatch of Pacific halibut in the west coast groundfish trawl fishery (2012–2017)
- Providing direct observation video camera systems to fishers for their use in evaluating industry-designed bycatch reduction devices (2012–2017)
- Seabird bycatch reduction through continuation of Seabird Bycatch Research Project to reduce potential fisheries interactions with short-tailed albatross and other seabird species (2012–2017)

15.12.11 NOAA Fisheries, Alaska Fisheries Science Center, Seattle, Washington

Contact: Craig Rose (craig.rose@noaa.gov)

More info: http://www.nmfs.noaa.gov/by_catch/bycatch_BREP.htm

Salmon Excluders

AFSC Conservation Engineering (CE) scientists participated in tests and refinement of the salmon excluder designs in February and March 2011. CE scientists provided and operated underwater video and sonar equipment to directly observe gear, assuring effective tuning of devices. Chinook salmon escape rates were between 25 and 40%, while chum salmon escape rates remained in the 10–15% range. Pollock escape was insignificant at less than 1%. The North Pacific Fisheries Research Foundation placed a technician aboard Gulf of Alaska vessels to demonstrate correct tuning and operation of the new excluder design to promote transfer of this technology to that fleet. The AFSC provided the camera systems used by this technician from our CE “loaner pool.” BREP funding was also used for travel to an autumn 2011 workshop at the fishing gear testing facility in St John’s, Newfoundland to develop new designs to improve escape rates for both salmon species.

Development and evaluation of trawl groundgears that produce less damage to crabs in soft bottom areas

In June, CE scientists conducted two weeks of tests of alternative footrope designs for flatfish capture efficiency and crab bycatch rates aboard the catcher/processor *Cape Horn*. The vessel’s twin trawling and catch handling systems allowed direct comparisons of catch rates on each tow. Preliminary results indicate that a conventional disk footrope had much lower crab bycatch rates than a comparable roller gear footrope (a result expected by fishers), but very similar flatfish catch rates (an unexpected result). In a second test, we found that widening disk spacing, and hence reducing ground contact and potential for crab damage, had little effect on flatfish catch rates.

In August, the same footrope designs were used in tests to determine the mortality rate of crabs passing under each of these footropes. Reflex scans were conducted on recaptured crabs and converted to mortality rates with a relationship between reflex loss and delayed mortality (RAMP) developed in prior years. Analysis of those results is not yet complete. During that cruise, we also conducted experiments to address concerns raised by fishers regarding the experimental methods for estimating escape mortality rates of crabs. They were concerned that exposure to suspended sediment during recapture behind the footropes could be causing additional mortality. We developed a way to expose crabs to the sediment and recapture process, without having to also contact a footrope. This provides a better control condition for

the mortality estimates, improving their scientific validity, as well as understanding and acceptance by affected fishers.

Mortality rates for crab bycatch in Gulf of Alaska trawls and applicability of sweep modifications to reduce crab mortality

CE scientists also evaluated Tanner crabs caught by commercial trawl vessels in the Gulf of Alaska to estimate crab bycatch mortality rates and applicability of mortality estimation methods from previous studies. A sample of the assessed crabs were held in both onboard and laboratory tanks to test how the RAMP relationship for bycatch crabs compared to the RAMP developed for escaping crabs after encountering trawls on the seabed. In combination with similar observations for Tanner and snow crabs during the Bering Sea cruise on the *Cape Horn*, described above, this provided the observations and validation tests to generate estimates of trawl bycatch mortality rates. Preliminary analyses confirm how such mortalities are related to handling time aboard the capture vessel. We also worked with captains to assess the implementation of trawl sweep modifications to the Gulf fleet for reducing crab mortality on the seabed. These improved estimates of crab bycatch mortality rates and information on applicability of sweep modifications will inform considerations of crab protection actions by the North Pacific Fisheries Management Council.

Future work

- Salmon bycatch reduction in Alaska pollock fisheries through development of trawl modifications (2012–2017)
- Pacific halibut bycatch reduction in Gulf of Alaska and Eastern Bering Sea groundfish (cod, flatfish, pollock) trawl and longline fisheries through development of fisheries-specific bycatch reduction devices (2012–2017)
- Crab bycatch reduction in groundfish fisheries through development of gear modifications (2012–2017)
- Seabed habitat and Essential Fish Habitat impact reduction by modifying trawls and trawling methods (2012–2017)
- Seabird bycatch reduction in Alaska trawl fisheries by further developing effective seabird mitigation gear, enhancing bycatch monitoring, exploring the role of vessel attraction and providing free seabird bycatch reduction gear (2012–2017)
- Seabird bycatch reduction in Alaska and Northwest longline fisheries by providing free streamer lines and cost-sharing on integrated weight lines (2012–2017)
- Reduction of unobserved crab mortality due to trawl encounters through development and implementation of modified trawl groundgear (2012–2017)

15.12.12 NOAA Fisheries, Pacific Islands Region and Pacific Islands Fisheries Science Center, Honolulu, Hawai'i

More info: http://www.nmfs.noaa.gov/by_catch/bycatch_BREP.htm

Acoustically Observing False Killer Whales in the Hawaii-Based Tuna Longline Fishery

Funds in 2011 were used to purchase a total of three High-frequency Acoustic Recording Packages (HARPs) developed by engineers at the Scripps Institution of Oceanography. These instruments are specifically designed for ease of use within the

fishery and will be used to detect the occurrence and nature of false killer whale interactions. The hard drive and internal 'guts' of the recorder have been condensed to fit in a small pressure case so that it may be easily and quickly deployed from a fishing vessel without slowing down the fishing process. Additionally, a salt water switch has been developed to enable data acquisition to begin immediately when the recorder enters the water. The first recorder prototype has been received and is currently being tested on the captive false killer whale and bottlenose dolphin at the Hawaii Institute of Marine Biology in Kaneohe, Hawaii. The first fishing trip deployment for this instrument occurred in early December, 2011. At the time of the writing of this report, the instrument was still at-sea, so no assessment of data quality or the occurrence of false killer whale interaction was available. Fishers are testing various attachment and deployment methods to determine the best configuration for future trips.

Evaluating the Physiological Status of Large Pacific Blue Marlin Captured in the Pacific Longline Fisheries: Implications for Post-Release Survival and Biochemical Correlates of Morbidity and Mortality

Our study will provide key estimates on the post-release mortality of blue and striped marlin captured in the Hawaii-based commercial longline fishery using a combination of pop-up satellite archival tags (PSATs) and biochemical correlates of morbidity and mortality. Specifically, the study will strive to tag and collect samples from larger individuals where estimates on post-release survival are lacking. To achieve statistical power, our goal is to acquire between 200 and 400 biochemical samples of marlin screened for biochemical marker with ~20 samples tagged with PSATs. To date, we have only acquired appreciable sample numbers (~n=80) on striped marlin for some 76 diagnostic markers. Due to availability and catchability, however, billfish sampling has been limited for shortbill spearfish (*Tetrapturus angustirostris*; ~n=25) and blue marlin (< n=10). Plasma levels of Na⁺, Ca²⁺, Cl⁻, phosphate each show little variation between species (SD are less than 10% of means). Mg is more variable, with several individual fish having levels as much as 10-times above baseline. Indices of muscle damage show that captured fish have experienced a considerable degree of muscle damage.

Future work

- Prediction of post-release survival in large pelagic fish (2012–2015)
- Examining the feasibility of weak hooks to reduce longline bycatch (2012–2015)
- False killer whale take reduction in the Hawaii-based pelagic longline fishery (2012–2017)

15.13 Discussion of National Reports

It was agreed that in subsequent years, a deadline would be set for National Reports prior to the start of the meeting to allow time for a summary to be presented. Mike Pol agreed to continue summarizing the National Reports following the conclusion of his term if the next chair desired it.

16 Other business

16.1 SELDAT database

SELDAT is a database consisting of selectivity data from 26 experiments consisting of 98 gear tests. Thirteen organizations worked on its creation from 1999 until 2003, at a cost exceeding € 800,000. The database was built by Cefas in Lowestoft UK in close cooperation with experts within the group and a project steering committee. Cefas have recently requested payment for costs associated with maintenance of the database of over £10,000 per year. WG members do not have access to this level of funding. Inquiries were made to the ICES Data Centre about transfer of the database to their servers, where no costs would be incurred by WG members. Reaction was generally positive, and a plan of action was developed. However, recent inquiries to Cefas indicate that costs would be associated with decommissioning, estimated by Cefas to be £7851 excluding VAT.

Discussion

It exists but will it be used? There may be a need for the data outside the group. Raw data would be ideal. It is in the archives of Cefas, but money is needed to extract it. ICES will be willing to host it. The discussion will continue by e-mail.

16.2 Theme Session Topics for ICES ASC 2013

The 'Science' on selective fishing and its effects on the ecosystem paper published in Nature was mentioned as a topic to consider by this group. The discussion on this may be developed further as a theme session. We may need time to see results, and the outcome may effects views in selective fishing tremendously. This science is still underdevelopment, maybe three years from now? Following the meeting, an alternative response was planned by several WGFTFB meeting.

A draft proposal for a theme session on Quantification of the Behaviour of Marine Animals in the Natural Environment: Observation Techniques, Analysis Methods, and Recent Progresses was developed by P. He, M. Pol, and H. Einarsson after the meeting.

16.3 2013 Annual Meeting

16.3.1 Location

Under the terms of the ICES-FAO exchange of letters, FAO has responsibility for organizing the 2013 meeting. Locations under consideration include Bangkok, Thailand, hosted by SEAFDEC, Latin America, and Rome. Discussion and input was solicited from participants on the suitability of locations, and on members' ability to gain funding and authorization to travel to Bangkok. It was confirmed through Bill Karp, SSGESST Chair that SCICOM will support in principle any location chosen by FAO.

FAO have committed to selecting a meeting location before the ICES Annual Science Conference in September 2012 as a courtesy to the SCICOM business meeting.

16.3.2 Meeting Structure

The exchange of letters between ICES and FAO regarding the FAO-organized meetings defines a mini-symposium format, with a list of topics intended to involve a global network of researchers. A discussion was held with WG members to broadly define a meeting structure. The recommendations of the group were:

- Duration of 6 days including one day of industry consultation.
- Meet on a Thursday, Friday, Saturday, Sunday (industry consultations), Monday, Tuesday.
- Conduct 2.5 days of mini-symposia in plenary.
- Suggested topics and conveners:
 - Low impact fuel efficient fishing.
 - Y. Matsuhita, T. Catchpole, B.van Marlen
 - The use of artificial light as a stimulus on fish behaviour in fish capture
 - H-C An, M. Breen, Latin American Expert.
 - Species selectivity of trawls in crustacean fisheries.
 - Species selectivity of trawls in crustacean fisheries.
 - P. He, experts from Pascagoula, Australia, or Mexico.
- Possibly include keynote speaker(s).
- Combination of talks and facilitated discussion.
- More focused theme and expected outcomes would need to be developed in collaboration with conveners.
- Three conveners per session.
- Posters might be included.
- One half day for ICES business:
 - The 2014 location.
 - Joint session with WGFAST.
 - Election of new Chair.
 - New topic groups, ASC sessions, AOB.
- One day for topic groups.
- Two half days for open session talks.

Discussion

The importance of adequate attendance in the first FAO hosted meeting under the new agreement was stressed during the discussion. The challenges of obtaining travel funding and approval in relation to budget cuts that may be expected and caps in travelling to cut carbon footprints was noted. The suggestion was made to use video conferencing; including a primary node in Rome at the FAO HQ should the meeting be held in Bangkok. This idea will be explored further, it may involve two locations, e.g. one in Europe and one in Asia. Time differences should be considered. A suggestion to hold the meeting in May instead of April was made.

16.3.3 Terms of Reference for 2013

16.3.3.1 New Terms of Reference

A WGFTFB topic group of experts will be formed in 2013 to investigate innovative dynamic catch control devices in fishing. Dynamic catch control systems are defined as catch control systems that change the structure and functioning of the gear during the fishing operation so that the gear stops collecting fish when desired amount of fish has entered the retention part of the gear, or actively releases excessive fish with least level of mortality. To be convened by Eduardo Grimaldo (Norway) and Mike Pol and Pingguo He (USA). The group will have the following terms of reference:

- i) Review the fisheries, conditions, and impact on mortality where dynamic catch control can be an advantage and consider/share recent improvements towards commercial fisheries.
- ii) Provide improvements/solutions for the challenges related to excessive catches that are encountered in the different fisheries and gears world-wide.
- iii) Produce a report including a review of the status of knowledge and technology on the subject, with identification of technology gaps, and recommendations for future research on the technology for the different fisheries and fishing gears.

16.3.3.2 Continuing Terms of Reference

- a) Incorporation of Fishing Technology Issues/Expertise into Management Advice. Based on the questionnaire exercise carried out since 2005/2006;
- b) A WGFTFB topic group of experts formed in 2012 will continue in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions. Specifically the group aims to:
 - i) Describe and summarize fish response to artificial light stimuli;
 - ii) Describe and summarize use of artificial light in world fisheries;
 - iii) Describe and tabulate different light sources to attract fish;
 - iv) Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions;
 - v) Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods;
- c) A WGFTFB topic group of experts, proposed and accepted in 2010, will be formed in 2012 to investigate relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries. The group will have the following terms of reference:
 - i) To review technical specifications of trawl gears used in different fisheries (benthic, demersal and pelagic) with attention, in particular, to the dimensions of floatline, groundrope, circumference or perimeter at various levels of the net, extension piece, codend, otterboard, and other aspects;
 - ii) To model and describe relations between engine power and gear-size characteristics of European trawl fleets. Modelling engine

power and different parts of the fishing gears as well as between some of these parts and the otter-board size should be investigated.

16.4 AOB and concluding remarks

No concluding remarks. Our hosts are thanked for all the work they have put in to make this meeting successful.

Annex 1: List of Participants

Name	Address	Telephone/Fax	E-mail
Michael Pol Chair	Mass. Division of Marine Fisheries Conservation Engi- neering & Fisheries Dependent Investiga- tions 1213 Purchase Street New Bedford MA 02740 United States	+1 5085631779 +1 5085635482	mike.pol@state.ma.us
Petri Suuronen Chair	The Food and Agricul- ture Organization of the United Nations FAO Fisheries and Aquaculture Depart- ment Viale delle Terme di Caracalla IT-00153 Rome Italy	+39 06 57055153	petri.suuronen@fao.org
Heui-Chun An	National Fisheries Research and Devel- opment Institute (NFRDI) East Sea Fisheries Research Institute 482, Sacheonhaean-Ro Yeongok-Myeon 210-861 Gangneung Gangwon-Do Republic of Korea	+82 33 660 8550 + 82 33 661 8514	anhc1@nfrdi.go.kr
Simon Arm- strong	Centre for Environ- ment, Fisheries and Aquaculture Science (Cefas) Cefas Brixham 55 Briseham Road Brixham, Devon TQ5 9NX UK		simon.armstrong@cefas.co.uk
Luis Arregi Errazkin	AZTI-Tecnalia AZTI Sukarrieta Txatxarramendi ugartea z/g E-48395 Sukarrieta (Bizkaia) Spain	+34 667 174409 +34 6870006	larregi@azti.es
Bjørn Erik Axel- sen	Institute of Marine Research Nordnes PO Box 1870 5817 Bergen Norway	47 552 36823	bjoern.erik.axelsen@imr.no

Name	Address	Telephone/Fax	E-mail
Gérard Bavouzet	Ifremer Lorient Station 8, rue François Toullec 56100 Lorient France	+33 297873830 +33 297873838	gerard.bavouzet@ifremer.fr
Mike Breen	Institute of Marine Research Nordnes PO Box 1870 5817 Bergen Norway	+47 55236930	michaelb@imr.no
Daragh Browne	BIM, Dun Laoghaire, Ireland		
Tom Catchpole	Centre for Environ- ment, Fisheries and Aquaculture Science (Cefas) Lowestoft Laboratory Pakefield Road Lowestoft, Suffolk NR33 0HT UK	+44 776 804 1107	thomas.catchpole@cefas.co.uk
Arill Engås	Institute of Marine Research Nordnes PO Box 1870 5817 Bergen Norway	+47 55236808 +47 55236830	arill.engas@imr.no
Chris Glass	University of New Hampshire Ocean Process Analy- sis Laboratory 142 Morse Hall 8 College Rd. Durham NH 3824 United States	+1 603 862 0122	chris.glass@unh.edu
Benoît Guerin	CCR-S 6, rue Alphonse Rio 56100 Lorient France	+33 2 97 88 09 40 +33 2 97 83 33 66	bguerin@ccr-s.eu
Pingguo He	School for Marine Science and Technol- ogy, University of Massachusetts- Dartmouth 706 South Rodney French Boulevard, New Bedford MA 02744 United States	+ 1 (508) 910-6323	phe@umassd.edu

Name	Address	Telephone/Fax	E-mail
Bent Herrmann	DTU Aqua - National Institute of Aquatic Resources The North Sea Science Park PO Box 101 9850 Hirtshals Denmark	+45 33 96 32 04	bhe@aqua.dtu.dk
Einar Hreinsson	Marine Research Insti- tute Skúlagata 4 PO Box 1390 121 Reykjavík Iceland	+354 575 2301	eihreins@hafro.is
Odd-Børre Humborstad	Institute of Marine Research Nordnes PO Box 1870 5817 Bergen Norway	+47 5523 6939	oddb@imr.no
Olafur A. In- golfsson	Marine Research Insti- tute Skúlagata 4 PO Box 1390 121 Reykjavík Iceland	+354 575 2303	olafur@hafro.is
Bjornar Isaksen	Institute of Marine Research Nordnes PO Box 1870 5817 Bergen Norway	+47 5523 6806	bjornar.isaksen@imr.no
Hjalti Karlsson	Marine Research Insti- tute Skúlagata 4 PO Box 1390 121 Reykjavík Iceland	+354 5752300 +354 8916472	hjalti@hafro.is
Ludvig Ahm Krag	DTU Aqua - National Institute of Aquatic Resources The North Sea Science Park PO Box 101 9850 Hirtshals Denmark	+45 33963206 +45 33963260	lak@aqua.dtu.dk
Svein Løkke- borg	Institute of Marine Research Nordnes PO Box 1870 5817 Bergen Norway	+47 55236826 +47 55236830	svein.lokkeborg@imr.no

Name	Address	Telephone/Fax	E-mail
Sven-Gunnar Lunneryd	Swedish University of Agricultural Sciences Institute of Marine Research Turistgatan 5 PO Box 4 453 21 Lysekil Sweden	+46 10 4981439 +46 70 6612596 (mob.)	sven-gunnar.lunneryd@slu.se
Bob van Marlen	Wageningen IMARES PO Box 68 1970 AB IJmuiden Netherlands	+31 317 487 181 +31 255 564644	bob.vanmarlen@wur.nl
Yoshiki Matsu-shita	Nagasaki University Faculty of Fisheries- Division 1: Systematic Fisheries Science 1-14 Bunkyo-machi 852-8521 Nagasaki-shi Japan	+81 095 819 2803	yoshiki@nagasaki-u.ac.jp
Sonia Mehault	Ifremer Lorient Station 8, rue François Toullec 56100 Lorient France	+33 297 873 852	sonia.mehault@ifremer.fr
Marc Meillat	Ifremer Lorient Station 8, rue François Toullec 56100 Lorient France	+33 297 873831	marc.meillat@ifremer.fr
Bernd Mieske	Johann-Heinrich von Thünen-Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries Institute for Baltic Sea Fisheries Alter Hafen Süd 2 18069 Rostock Germany	+49 381 811 6122	Bernd.mieske@vti.bund.de
Hans Nilsson	Swedish University of Agricultural Sciences Institute of Marine Research Turistgatan 5 PO Box 4 453 21 Lysekil Sweden	+46 1047 84040 +46 52313977	hans.nilsson@slu.se
Emilio Notti	CNR - National Research Council Institute of Marine Science Largo Fiera della Pesca, 1 IT-60125 Ancona Italy	+39 712078830 +39 3397007963	e.notti@an.ismar.cnr.it

Name	Address	Telephone/Fax	E-mail
Barry O'Neill	Marine Scotland Science Marine Laboratory 375 Victoria Road PO Box 101 Aberdeen AB11 9DB UK	+44 1224295343 +44 1224295511	barry.o'neill@scotland.gsi.gov.uk
Anne Christine Utne Palm	Institute of Marine Research Nordnes PO Box 1870 5817 Bergen Norway	+47 552 38673	annecu@imr.no
Alexander Pavlenko	Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO) 6 Knipovitch Street 183038 Murmansk Russian Federation	+781 5252 3178	pavlenkorybak@gmail.com
Daniel Priour	Ifremer Centre de Brest Technopole de Brest-Iroise PO Box 70 29280 Plouzané France		daniel.priour@ifremer.fr
Manu Sistiaga	SINTEF Fisheries and Aquaculture Brattørkaia 17C 7465 Trondheim Norway	+47 91 66 34 99 +47 93 27 07 01	manu.sistiaga@sintef.no
Daniel Stepputtis	Johann-Heinrich von Thünen-Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries Institute for Baltic Sea Fisheries Alter Hafen Süd 2 18069 Rostock Germany	+49 381 8116 136 +49 381 8116 199	daniel.stepputtis@vti.bund.de
Maria Tenningen	Institute of Marine Research Nordnes PO Box 1870 5817 Bergen Norway		maria.tenningen@imr.no
Francois Theret	Scapeche SA- The Maritime Network 6, rue du Bout du Monde 56326 Lorient France	+33 2 97 37 10 11 +33 6 74 63 52 04	ftheret@comata.com

Name	Address	Telephone/Fax	E-mail
Benoit Vincent	Ifremer Lorient Station 8, rue François Toullec 56100 Lorient France	+33 2978 73804	benoit.vincent@ifremer.fr

Annex 2: Agenda

Study Group

21 – 22 April	9:00	17:00
	SGELECTRA (Times at discretion of SG chair, B. van Marlen)	

WGFTFB

23 April, Monday

8:00	9:00	Registration
9:00	9:30	Opening address and meeting housekeeping
9:30	10:30	Report from ICES (Mike Pol)
10:30	11:00	Body and Mind Break (Coffee)
11:00	12:00	Report from FAO (Petri Suuronen)
12:00	13:30	Lunch (on your own)
13:30	13:50	Summary of SGTCOD (Bent Herrmann)
13:50	14:10	Summary of SGELECTRA (Bob Van Marlen)
14:10	14:30	Consideration on Low Impact and Fuel Efficient Fishing: Interaction between Squid Jigging and Large-scale Fish Trap Fisheries in western Japan (Y. Matsushita, D. Masuda, P. Suuronen)
14:30	14:50	Energy efficiency analysis for Italian fishing vessels through an Energy Audit tool (E. Notti)
15:00	15:30	Body and Mind Break (Coffee)
15:30	15:50	Development of catch control devices (E. Grimaldo)
15:50	16:10	A Low-Cost, Underwater Self-Closing Codend to Limit Unwanted Catch (M. Pol)
16:10	16:40	A decade of research on the Gulf of Maine shrimp trawls to reduce finfish bycatch and small shrimps (P. He)
16:40	17:00	Closing
17:30	18:00	Official Welcome

24 April, Tuesday

9:00	9:15	Housekeeping issues
9:15	9:25	Introduction to ToR D INNOVATION
9:25	9:35	Introduction to ToR C ARTIFICIAL LIGHTS
9:35	9:45	Introduction to ToR B REDFISH
9:45	10:00	Introduction to ToR A ADVICE
10:30	11:00	Body and Mind Break (Coffee)
11:00	11:20	A Study of Square Mesh Codends in English Otter Trawlers (T. Catchpole)
11:20	11:40	Quantifying fish escape behaviour through large mesh panels in trawls based on catch comparison data: model development and a case study from Skagerrak (L. Krag)
11:40	12:00	Investigation on escapement efficiency through a square mesh panel: effects of panel overlap with catch accumulation and of an attempt to stimulate the escape behaviour (B.

Herrmann)

12:00	13:30	Lunch (on your own)
13:30	13:50	Slipping herring from purse-seines – A source of unaccounted mortality or a potentially responsible way of controlling the catches? (M. Tenningen)
13:50	14:10	Predicting and mitigating the impact of towed gears – a case study with a clump weight (F. O'Neill)
14:10	14:40	Catch comparison of pulse trawls vessels and a tickler chain beam trawler (B. van Marlen)
14:40	15:00	Measuring sediment mobilization by fishing gears using a multi beam echosounder (F. O'Neill)
15:00	15:30	Body and Mind Break (Coffee)
15:30	15:50	TBD (B. Vincent and F. Theret)
15:50	16:50	Synthesis of International Fishing Gear Laboratories Organization (G. Bavouzet and S. Mehault)
16:50	17:00	Closing

25 April, Wednesday

9:00	9:05	Housekeeping issues
9:05	10:30	Topic Group meetings
10:30	11:00	Body and Mind Break (Coffee)
11:00	12:00	Topic Group meetings
12:00	13:30	Lunch (on your own)
13:30	15:00	Topic Group meetings
15:00	15:30	Body and Mind Break (Coffee)
15:30	17:00	Topic Group meetings
15:30	18:30	Social Event

26 April, Thursday

9:00	9:05	Housekeeping issues
9:05	10:30	Topic Group meetings
10:30	11:00	Body and Mind Break (Coffee)
11:00	12:00	Topic Group meetings
12:00	13:30	Lunch (on your own)
13:30	15:00	Topic Group meetings
15:00	15:30	Body and Mind Break (Coffee)
15:30	17:00	Topic Group meetings

27 April, Friday

9:00	9:20	Summary of National Reports
9:20	9:50	ToR A ADVICE: Report, conclusions and recommendations
10:10	10:30	ToR D INNOVATION: Report, conclusions and recommendations
10:30	11:00	Body and Mind Break (Coffee)

11:00	11:20	ToR B REDFISH: Report, conclusions and recommendations
11:20	11:40	ToR C LIGHT: Report, conclusions and recommendations
12:00	13:30	<i>Lunch (on your own)</i>
13:30	14:15	ToRs for 2013
14:15	15:00	Suggestions for ASC theme session topics 2013
15:00	15:30	<i>Body and Mind Break (Coffee)</i>
15:30	15:45	Date and venue for WGFTFB 2013 meeting
15:45	16:00	AOB and Concluding remarks (Chair)

*Topic Groups and Associated Conveners

A. Topic Group on Incorporation of Fishing Technology Issues/Expertise into Management Advice

Conveners: Michael Pol (USA) and Dominic Rihan (EC)

B. Topic Group on Redfish Fishing Technology and Physiology

Conveners: Bent Herrmann (DK) and Pingguo He (USA)

C. Topic Group on Use of Artificial Lights in Fisheries

Conveners: Heui-chun An (KR), Mike Breen (NO), and Pingguo He (USA)

D. Topic Group on Innovation in Fishing Gear Technology

Convener: Bob Van Marlen, (Netherlands)

Annex 3: WGFTFB terms of reference for the next meeting

The ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB), chaired by Michael Pol, USA, and Frank Chopin, FAO, will meet in a location to be determined in 2013 to:

- a) Incorporation of Fishing Technology Issues/Expertise into Management Advice. Based on the questionnaire exercise carried out since 2005/2006;
- b) A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions. Specifically the group aims to:
 - i) Describe and summarize fish response to artificial light stimuli;
 - ii) Describe and summarize use of artificial light in world fisheries;
 - iii) Describe and tabulate different light sources to attract fish;
 - iv) Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions;
 - v) Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods;
- c) A WGFTFB topic group of experts will be formed in 2012 to investigate relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries. The group will have the following terms of reference:
 - i) To review technical specifications of trawl gears used in different fisheries (benthic, demersal and pelagic) with attention, in particular, to the dimensions of floatline, groundrope, circumference or perimeter at various levels of the net, extension piece, codend, otterboard, and other aspects;
 - ii) To model and describe relations between engine power and gear-size characteristics of European trawl fleets. Modelling engine power and different parts of the fishing gears as well as between some of these parts and the otter-board size should be investigated.
- d) A WGFTFB topic group of experts will be formed in 2013 to investigate innovative dynamic catch control devices in fishing. Dynamic catch control systems are defined as catch control systems that change the structure and functioning of the gear during the fishing operation so that the gear stops collecting fish when desired amount of fish has entered the retention part of the gear, or actively releases excessive fish with least level of mortality. To be convened by Eduardo Grimaldo (Norway) and Mike Pol and Pinguo He (USA). The group will have the following terms of reference:
 - i) Review the fisheries, conditions, and impact on mortality where dynamic catch control can be an advantage and consider/share recent improvements towards commercial fisheries.
 - ii) Provide improvements/solutions for the challenges related to excessive catches that are encountered in the different fisheries and gears world-wide.

- iii) Produce a report including a review of the status of knowledge and technology on the subject, with identification of technology gaps, and recommendations for future research on the technology for the different fisheries and fishing gears.

WGFTFB will report by a date to be determined in 2013 (via SSGESST) for the attention of SCICOM and ACOM.

Supporting Information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
Scientific justification	<p>Term of Reference a)</p> <p>Fisheries management bodies are often dependant on catch per unit of effort for stock assessment purposes and fishery/fleet based advice. Identification and use of gear parameters that effect fishing efficiency will most likely improve the use of commercial catches for stock assessment purposes. WGFTFB has the expertise to identify such parameters and will work intersessionally, reviewing existing initiatives e.g. EC data collection regulation and provide a list for consideration during the 2010 WGFTFB meeting. The information collated by the WGFTFB has been well received by ICES assessment and other Expert Groups. It is intended to continue with the collation of this information but further developments are needed. WGFTFB has recommended a number of changes to improve the utility and simplicity of this work. The next questionnaire will be based on the emergent issues identified in this report, and focused on 2011/2012. Feedback on the content and value of this year's report will be sought from the Assessment working groups and through WGCHAIRS and will be used to improve the survey in 2012. If possible, the EC should be asked to provide up to date information on recent TCM regulations. These will be included in the survey with a request to detail likely outcomes from these measures.</p> <p>Term of Reference b)</p> <p>Light has been used in fishing for more than one hundred years. Difference fish/shellfish species respond to light differently, and some do not respond at all. Commercial applications of light in purse-seines, lift nets, and squid jigging are widely practiced, especially in Asian-Pacific countries. Fishing lamps such as incandescent lamps, metal halide lamps or fluorescent lamps are commonly used in these fisheries. Different light intensities are used on different fishing grounds targeting a variety of marine fish and invertebrate species. Studies on different light outputs have been conducted including analysis of fishing efforts and catch, underwater light intensity, and monitoring of capture processes. Impacts from light fishing may include lighting power competition, cost impact due to high fuel consumption, environmental impact due to CO2 emission, and biodiversity.</p> <p>Various light sources are utilized to attract or repel target or non-target fish in the capture process. As new energy efficient light sources are invented and developed rapidly, new applications of light sources might be used to develop energy efficient and environmentally friendly fishing methods. Attractions of plankton, which are prey for fish, that are caught in passive gears are one possible application. Repelling of fish by light of certain strength or colour in a trawl might improve herding efficiency as well as decreasing weight of the gear and thus drag forces, leading to less energy consumption in trawling.</p> <p>A synthesis of the knowledge will provide up-to-date information on the</p>

field, and stimulate researchers for innovative application in modern day fishing gear designs in managing bycatch, reducing discards and fostering sustainable fisheries. The topic will also stimulate east-west information exchange in fishing technology.

Term of Reference c)

WGFTFB is a joint ICES/FAO WG with a wide range of gear technology expertise and terms of reference which include consideration of technical issues related to fisheries around the world. Recent WGFTFB reviews of different fisheries have shown that technological advance is becoming a major issue. There are also indications that technological advance is accelerating and that it is often leading to an increase in catching efficiency.

A current EU goal is to develop a common fishery management policy for the EU nations. Collection of updated information on the characteristics of trawlnets used in different European fisheries, with a view to establish limitation in the maximum dimensions of the trawl fishing gears, will contribute to limit the fishing effort and to minimize the environmental impact of these fishing gears.

In this context, the establishment of an ad-hoc topic group on the technical issues concerning all European fisheries will increase also cooperation and transferring technical knowledge among all the countries. The technical issues will cover only those within the remit of WGFTFB.

The study must be carried out on the basis of the information collected in relevant fishing fleets with the collaboration both of the fishing sectors. Information must also be independently collected through the netmakers. Results from research projects and studies, funded either with national or/and EU support, must be used in view of establishing synergies among different scientific domains while avoiding duplications

Term of Reference d)

Current activities within the institutes of several members of WGFTFB suggest that dynamic catch control is an important issue for several fisheries worldwide. Excessive catches are an acknowledged problem that result in increased mortality, reduced fish quality, and minimized fishing opportunities. Solutions pertaining to catch control are required by the authorities and fishers of different countries.

Several countries have conducted or are planning significant studies in this field but major improvements to the solutions presented are still needed. The creation of such a group would improve the cooperation between countries and institutes and would act as a SharePoint for the progress in the field.

Excessive catches are a problem, first of all because they often exceed the processing capacity of the vessel and consequently affect the quality of the fish delivered. In fisheries supplying fish for aquaculture where the fish needs to be taken onboard alive, excessive catches present an additional problem because of the lower survival chances of the fish when excessive amounts of fish are caught. In addition, excessive catch amount can lead to serious health, safety and environmental (H.S.E) concerns. In individual or group quota fisheries, excessively large catch can lead to diminished fishing opportunity for other species.

Excessive catches have so far been related to trawls, Danish seines and purse-seines, which demonstrates that this is a global problem in fisheries. Solutions for such a global issue will contribute to more responsible fisheries worldwide and reduced unaccounted fishing mortality through the reduction of discards.

Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 40–60 members and guests.

Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	The questions of bycatch reduction, gear selectivity, gear monitoring, fisheries information and survey trawl standardization are of direct interest to ACOM
Linkages to other committees or groups	This work is of direct relevance to the Working Group on Ecosystem Effects of Fisheries, WG on Fishery Systems, WG on International Bottom Trawl Surveys, Baltic Committee, Marine Habitat Committee, Resource Management Committee and Living Resources Committee and the Assessment Working Groups.
Linkages to other organizations	The work of this group is closely aligned with similar work in FAO, GFCM, NAFO and also the EU Regional Advisory Councils.

Annex 4: Recommendations

Recommendation	Addressed to
1. Distribute fisheries advice to Expert Groups as detailed in Section 10.4 and Annex 5: WGFTFB information for other ICES expert groups and questionnaire sent to WGFTFB members.	ICES Secretariat
2. Approve change in ToRs relating to topic group on Use of Artificial Light in Fishing detailed in Section 12.9.	SSGESST/SCICOM
3. Approve discontinuation of ToRs on Redfish Fishing Technology and Physiology and Innovation in Fishing Gear Technology.	SSGESST/SCICOM
4. Approve a new ToR on Dynamic Catch Control Devices in Fishing, continuing ToRs on Incorporation of Fishing Technology Issues/Expertise into Management Advice, and reestablishment of delayed ToRs on relationships among vessel characteristics and gear specifications in commercial fisheries (Section 16.3.3.1).	SSGESST/SCICOM
5. Note the suggested work plan and possible locations for the FAO-hosted 2013 WG meeting (Section 8).	SSGESST/SCICOM

Annex 5: WGFTFB information for other ICES expert groups and questionnaire sent to WGFTFB members

Questionnaire

Rationale:

Please fill out the attached form in regards to **ToR A: Incorporation of Fishing Technology Issues/Expertise into Management Advice**. This questionnaire contains a series of questions relating to recent changes within the fleets in your particular country that you may have observed. It also gives you the opportunity to raise any issues that you think are important but are not currently recognized. In previous years, this information was only requested from EU nations. I am expanding it to include all participating nations, including North America. Even if you only have anecdotal or casual knowledge of fleet changes, please complete the attached questionnaire. You may also answer the questionnaire using an online form: <http://tinyurl.com/3on54sj>.

Introduction

This questionnaire contains a series of questions relating to recent changes within the fleets in your particular country that you may have observed. It also gives you the opportunity to raise any issues that you think are important but are not currently recognized.

If at all possible, please try to quantify your statements or state how the information has been derived e.g. common knowledge, personal observations, discussions with industry etc. Please try to keep your comments restricted to information in the period 2010–2012.

a. Changes in Fleet Dynamics between 2010 and 2012

Please describe any geographical or temporal shift in activity, change in gear type or shift in target species you are aware of.

Please describe the principal driving factors for this change (for example, management measures, effort allocation, fuel costs)

Has there been any removal of effort through decommissioning schemes? If yes, which fleets have been affected and has the decommissioning affected older or newer vessels or a combination of both? If so, what proportion of the fleet has opted for decommissioning (express as a percentage of the total fleet)

Have any new vessels entered the fleet?

b. Technology Creep

Include such issues as new gear handling methods/equipment; switch from single to multiple trawling; changes in vessel design that could affect effort; new fish finding equipment; etc..

Describe any significant changes in gear usage in specific fisheries (e.g. switch from twin to single rig trawling, beam trawl to seine net).

In which fishery has this change occurred and, if relevant, in what ICES areas?

Describe any other technical changes that may have occurred in particular fleets that will have resulted in changes in catching efficiency (e.g. changes in fishing pattern,

new gears or navigational equipment). Has the change in catchability been quantified?

Describe any evidence of vessels adapting their operations to improve fuel efficiency.

c. Gear Based Technical Conservation Measures

Other important information could include the level of uptake of TCMs if voluntary, the selectivity of these TCMs and how it compares with earlier estimates, and any other wider benefits e.g. reduced fuel costs, ecosystem benefits etc.

Describe any new TCMs that have been introduced into specific fisheries. What are the measures and which fleets and/or areas are affected? Please specify regulations (national or otherwise) and fishery. Have individuals or groups of fishers introduced TCMs at their own initiatives, and if so, why?

Report any incentives that have been introduced to promote the use of more selective gears. Which fleets/areas are targeted and what are the incentives (e.g. additional effort allocations for use of Swedish grids/SMPs)?

What proportion of the fleet has opted to use new TCMs?

Can changes in size or species selectivity be quantified relative to 'standard' gears? What are the changes? (e.g. shift in L50, per cent reduction in bycatch)

d. Ecosystem Effects

Describe any fisheries not previously reported where there are known impacts on non-target species including seabirds and marine mammals, ghost fishing etc.

Describe any measures in place to reduce benthic impact.

Describe any mitigation measures in place and their effectiveness

Have these new fisheries removed effort from others? If so, please provide an estimate in terms of numbers of vessels.

e. Development of New Fisheries

Describe any change in discard patterns in the fishery.

Briefly describe any new fisheries developed in the period 2010–2012.

FTFB report to WGCSE and WGHMM

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Northern Shelf and Southern Shelf Assessment Areas including the Irish Sea and the Celtic Sea.

It should be noted that the information contained in this report does not cover fully all fleets engaged in Northern and Southern Shelf fisheries; information was obtained from Ireland, France, UK, Netherlands, and Spain.

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); system

effects; and the development of new fisheries in the Southern Shelf for hake, monkfish and megrim stocks.

Fleet dynamics

- Over the period 2009–2011 there have been continuing shifts in fleet dynamics observed in the Basque fleet. Effort by this fleet (single and pair trawlers) has been concentrated in ICES Areas VIIIa,b,d from October to February. From late March and June 50% of the single trawlers (4 of 8 boats) have moved from VIIIa,b,d to Area VI. (Spain (Basque): Implications: Shifts in gears and areas).
- In the Basque pair trawl fleet targeting hake, vessels are tending to make shorter trips, due to low market price. Shorter fishing trips improved the fish freshness and quality. Also, it has been observed that vessels are coordinating their landing times in base ports sequentially during the week, avoiding, spreading supply over the week rather than concentrating landings on Mondays and Thursdays as was traditional practice. Auctions are being held throughout the week which has the potential to raise the market price of the catch. (Spain (Basque): Implications: Shifts in fishing patterns driven by market requirements).
- There are continued indications that Spanish bottom trawlers have varied their spatial-temporal fishing strategy in order to avoid mackerel in their catches, which can be significant at times. This is because of a reduction in the Spanish mackerel quota in 2011 due to an overshoot of the quota in 2010. (Spain: Implications: Reduced bycatch of mackerel).
- As in 2010 the Basque artisanal fleet operating on tuna (trolling lines) and mackerel (handlines) all year, traditional fishing patterns were spread over 8–9 months with about 3–4 months on mackerel and 4–5 months on tuna. The rest of the year the fleet was tied-up. Reductions in the mackerel quota in 2011 has reduced the mackerel season by 1–2 month season for this species and some boats have started fishing with other gears (longlines, gill-nets) to fill out the year activity. (Spain (Basque): Implications: Shift of effort into other fisheries due to quota restrictions).
- In the period 2010–2012 about 20% (4 from 12 vessels) of the single trawl fleet and the same percentage from the Basque pairtrawler fleet have been decommissioned (1 from 4 pairs) some of these vessels were relatively modern being around 10 years old. (Spain (Basque): Implications: Fleet reductions as a result of decommissioning).
- A sixty days fishing closure for Spanish trawlers operating in NW Iberian waters entered into force in April 30 2011. This cessation of activities is in addition to the thirty day closure included under the Hake and *Nephrops* recovery plan. Vessels must tie-up for this 60 day period between the date of entry into force and 31 October 2011. It can be divided into 4 periods of 15 days duration each (Spain: Implications: Reduction in fishing effort by Spanish trawler fleet).
- The 5 whitefish trawlers (> 24m) based in Greencastle in the NW Ireland which traditionally have regularly shifted between fishing areas (Area VIa, VIb, VIIb-k) at short notice depending on fishing opportunities have tended to concentrate efforts on their local grounds in VIa due to the price of fuel. Two of the larger of these vessels are finding it increasingly diffi-

cult to remain viable given the high operating costs. (Ireland: Implications: Shift in effort back to VIa).

- Effort levels in the Irish TR2 (Nephrops vessels) sector in the Irish Sea was exhausted in October 2011 meaning the majority of the fleet bar three vessels using sorting grids were prevented from fishing in the Irish Sea. Up to 16 vessels subsequently applied to fish using the sorting grid to gain some level of access to the fishery. This forced tie-up affected up to 40 Irish vessels and was particularly controversial given vessels from Northern Ireland continued to fish unrestricted during this period. (Ireland: Implications: Closure of fishery).
- With the current fuel prices, many Irish vessels have switched from targeting megrim, monkfish and hake to Nephrops to try to reduce operating costs. Some of the larger 20m+ vessels are particularly affected and as a result fishing effort in the Nephrops fisheries in the Smalls, Aran grounds, Porcupine and Labadie Bank will increase. (Ireland: Implications: Shift of effort from mixed demersal species to Nephrops)
- Five Irish whitefish vessels (24m+/700hp+) were granted an exemption from the effort regime in Area VIa (West of Scotland) in 2011. This represents around 95% of the active Irish vessels in this area. This exemption was granted on the basis that these vessels did not fish in an inshore area of the Donegal coast with historically high cod catches. These vessels must use 120mm mesh size and 120mm (9–12m) square mesh panels inside a restricted area inside the so-called "French Line" but can use 100mm+90mm smp outside this area. These vessels have been subject to enhanced coverage by scientific observer sampling which has shown an increase in cod catches with several trips observed to have cod catches in excess of 1.5%. This is primarily because of one vessel which has tended to fish in an area more likely to have cod bycatch. On this basis these vessels may lose their effort exemption in 2012 (Ireland: Implications: Inclusion of vessels back under the effort regime).
- Despite high fuel costs and quota and effort restrictions at least 6 modern second-hand vessels have entered the Irish fleet. The largest of these is 23m/580kw freezer vessel. All of these vessels will primarily target Nephrops. (Ireland: Implications: Entry of modern second-hand vessels).
- Two 20m Irish vessels have been tied-up since early 2011 due to discrepancies between their rated and actual engine power. It is likely other Irish vessels will also be tied up due to similar anomalies between actual and reported engine power (Ireland: Implications: Tie-up of vessels).

Technological Creep

- There have been repeated attempts by the Basque fleets to reduce operating costs by diversifying into other fisheries but with only limited success. Driven by the reduction in the mackerel quota this has been extended to the trolling and handline fleets that have diversified into longlines and purse-seines fisheries in ICES Area VIIIc. (Spain (Basque): Implications: Diversification)
- A project under the European Fisheries Technology Platform (EFTP) is looking at better mechanization of coastal longline fisheries, particularly for the large fleet of Spanish vessels that longline for hake and other species. The objective is to allow automatic baiting with more heterogeneous bait such as

sardines, shrimp; improve operational efficiency on board and also adapting automatic systems to handle monofilament line which has been a problem in the past. (Spain: Implications: Increased efficiency in coastal longline fisheries).

- There have been continued efforts by Irish, UK, Spanish and French demersal trawlers to reduce fuel costs through the use of more energy efficient gears. Modifications tested include hydrodynamic/low impact trawl doors, dynex warps, low drag twines and reductions in the size of trawls used. In addition there have been changes in fishing operations through slower steaming to and from grounds, fishing closer to home ports and other fuel saving measures. The actual impacts on fishing effort are difficult to predict but this is likely to be a continuing trend. However, as a result of one project in France (EFFICHALUT) an energy efficient trawl has been developed and is now being used by 15 whitefish trawls. The anticipated annual savings from these 15 vessels is estimated at €800,000 per year. (Ireland, UK, Spain and France: Implications: Improved energy efficiency)

Technical Conservation Measures

- Up to 11 Irish vessels (~16–20m/350–500kw) are now voluntarily using the “Swedish” sorting grid in the Nephrops fisheries in the Irish Sea (Area VIIa) although there is no real restriction in days at sea for these vessels following the outcome of the December Council when the baseline efforts were re-aligned. These vessels are exempt or in the process of being exempted from the effort restrictions currently in force in this area. Continued observations carried out show cod catches with the grid to be consistently less than 0.1% per trip and with Nephrops making up more than 95% of the catches with the grids. Up to 30% of the fleet working in the Irish Sea is now using grids (Ireland: Implications: Use of selective gear).
- Trials in Ireland with the Danish style SELTRA trawl with a large mesh square mesh panel installed in a 4-panel section and placed to the codend have shown that reductions in 70% or more in cod catches can be achieved. Similarly testing with a semi-flexible grid in the Nephrops fishery in the Irish Sea have shown this device is as effective as the standard rigid sorting grids currently being used in these fisheries (Ireland: Implications: Testing of different selection devices).
- Annually since 2009 daily or weekly quotas (depending on the fishery) have been introduced by the fishers in the Basque mackerel fishery (handliners and purse-seiners) and in the anchovy fishery (purse-seiners). These initiatives come from the fishers and are designed to stabilize or increase first sell price (Spain (Basque): Implications Voluntary conservation measures).
- French vessels have been involved in ongoing trials in the Bay of Biscay in the Nephrops fishery, primarily to improve escapement of juvenile hake and Nephrops selectivity. Devices such as square mesh cylinders, flexible grids, square mesh panels and a combination of the devices have been tested and the results show reductions in hake discards of between 20–40%. Trials have been ongoing in France in the English Channel and North Sea on cod and whiting selective devices (large mesh “eliminator” trawls, flexible grids – SELECMER and SELECCAB project). There have also been

trials to test a system of real-time closures to protect cod stocks in the North Sea. Results have been highly variable and the reductions in marketable catches remain a barrier to uptake. (France: Implications: Testing of selective gears).

- Under a French project Target-strength measurements for anchovy and sardine have been collected using a towed body "EROC" and an open pelagic trawl termed "ENROL". Up to these measurements no accurate Target Strength values existed for these species. (France: Implications: Improved survey techniques)

Ecosystem Effects

- Due to combination of low prices and quota restrictions many Irish vessels (both gillnetters and trawlers) are discarding marketable hake < 60cm. (Ireland: Implications: High-grading of hake)
- Discarding of juvenile haddock and whiting has been very high in the Celtic Sea in quarters 3 and 4 of 2011 and quarter 1 of 2012. This is due to very large year-classes of these species coming through into the fishery. There are reports of boats catching 2–3 tonnes to every 1 tonne retained. Attempts have been made in Ireland to introduce incentives for fishers to take remedial methods by offering extra quota for vessels signing up to using more selective gears. Some positive steps have been taken in relation to some of the Nephrops fleet but other vessels (particularly the seiners) are more reluctant to improve the selectivity of their gears on the basis that losses of marketable fish will be too high (Ireland: Implications: High discarding).
- During 2011 and 2012 national regulations have prohibited all catches of mackerel catch to all the national fleets until 15 February. The trawl fleet operating in ICES VIIIc and usually fishing mackerel at the beginning of the year were subsequently obliged to discard large quantities of mackerel because in that season mackerel is abundant in the areas where this fleet operates. (Spain (Basque): Implications: High discarding).
- As reported in previous years from Ireland and the UK predation of fish catches by mainly Grey seals from gillnet/tanglenet fisheries continues to be a problem on all coasts of the UK and Ireland. Many inshore fishers have now stopped gillnetting as the level of damage is so high. A current Irish study is currently assessing the level of seal depredation in inshore fisheries around Ireland and has reported some seal bycatch along with depredation. This study is due to be completed in 2012. (Ireland and UK: Implications: Increased predation by seals).
- Observer programmes in the Irish pelagic trawl fisheries (mackerel, horse mackerel, blue whiting, herring, and albacore tuna) implemented since 2005 have shown cetacean bycatch in these fisheries to be virtually non-existent. Only a bycatch has been observed in the tuna fishery and none at all in the last 2 years (Ireland: Implications: Low cetacean bycatch).
- The UK has been testing an acoustic deterrent device (DDD-O3L) which has proved highly effective in reducing bycatch in the >12m gillnet fisheries in ICES division VII (e, f, g, h and j). The UK authorities are planning to make the use of this device mandatory in these fisheries. (UK: Implications: Reductions in cetacean bycatch).

- A modified scallop dredge (N-VIRO) was tested against a standard tooth bar dredge on the southeast and west coast of Ireland. The results of these trials suggested the N-VIRO dredge to be more fuel efficient with less benthic impact and less damage to scallop. There was no reduction in catches associated with this dredge (Ireland: Implications: Low impact scallop dredge).

New Fisheries

- During 2010 and 2011, mainly in winter the squid has been abundant in coastal waters around northern Spain. Some artisanal vessels have carried out trials in this area during the night with jigging gear and artificial lights. If this fishery can be developed then it could lead to diversification away from traditional gillnet and longline fisheries in the area (Spain (Basque) Implications: Development of a new fishery for squid).

FTFB report to WGNSSK

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the North Sea, Skagerrak and Kattegat.

It should be noted that the information contained in this report does not cover fully all fleets engaged in North Sea fisheries; information was obtained from Scotland, France, Netherlands, Belgium, Sweden, Denmark and Norway.

Fleet dynamics

- It is now apparent that within the Netherlands, driven primarily by the cost of fuel, there is huge demand to use the pulse trawl and the number of vessels applying to fish under the 5% derogation far exceeds the number of licences available. Vessels not using the pulse trawl in the Netherlands are finding it increasingly difficult to get financial support from banks on economical (high fuel prices making beam trawling uneconomic) and ecological grounds (beam trawls are portrayed negatively). A total of 42 licences have been given out by the Dutch Ministry for pulse trawling. The majority of these licences are for flatfish beam trawls although 2–3 vessels are involved in trials to test the Belgium "HOVERCRAN" system. (Netherlands: Implications: Switch from beam trawling to pulse trawling).
- Measures to reduce fuel costs in the Dutch fleet have been continuing since 2008 from 35% (now 50 M€) to 25% in 2009 due to adaptations in gear and operation. Reports show that the use of the SumWing can save up to 300 tonnes of fuel per year per boat (Loa = 40 m), and with the pulse trawl up to 800–1000 tonnes annually. Up to 78 Dutch beam trawlers now used the SumWing with 28 of these using the Pulse/Wing trawl. A further 12 Dutch registered vessels in the UK, 2 in Germany and 5 in Belgium are also using the Sum Wing with 3 of these using the dual Pulse/Wing. (Netherlands: Implications: Switch to more fuel efficient gear).

- The use of the SumWing, Pulse Trawl and Pulse/Wing beam trawls are reported to have resulted in a shift in grounds in ICES Area IV, and also add fishing time, due to faster hauling speed. This is not well documented but may result in increased a change in effort patters and increased fishing time (Netherlands: Implications: Improved fuel efficiency).
- A recent analysis carried out in the Netherlands has measured the relative changes in catching efficiency between the pulse trawl and the standard beam trawl in numbers caught per hour. This analysis has shown a reduction in catching efficiency for plaice of around 25–30%; for sole 20–25% with a reduction in discards of 55–60% and a reduction in benthos of 35–40%. (Netherlands: Implications: Changes in catching efficiency).
- There are a smaller number of vessels in Belgium, Germany and the UK (Dutch owned) using the pulse trawl. However, the derogation only allows it to be used in the south of the North Sea and this has hindered the uptake of the gear in Belgium as they have only a limited sole quota in this area. (Belgium: Implications: Lower uptake of pulse trawl).
- The shift to Danish/Scottish seining has continued in a number of countries. This is driven by high fuel prices: There are now around 16 Dutch vessels operating in the North and the South North Sea, while there are around 12 French vessels now converted to Danish seining. (France: Implications: Shift from trawling to Seining).
- At least two Dutch beam trawlers have been converted into dual purpose vessels with the capability of fishing with twin-rigs and beam trawls. The idea is to increase the fishing opportunities for these vessels and allow them to switch between fisheries at different time of the year. (Netherlands: Implications: Dual purpose fishing vessels).
- In Norway there has not been any removal of fishing effort through decommissioning but the number of vessels has reduced due to movement of quota from newer and bigger vessels. In particular the medium and larger sized seine net fleets are being renewed. Altogether 3–4 new large white-fish trawlers, 4–5 pursers, 7–9 large seine netters and a large number of coastal vessels have entered the fleet over the period 2010–2012. While not measured it is likely that capacity and effort have increased. (Norway: Implications: Increases in fishing effort).

Technology Creep

- As reported the use of the SumWing and Pulse trawl are widespread now in the Netherlands. This is driven by high fuel costs with reported savings ranging from 10–50% from a combination of the gear and lower towing speeds. (Netherlands: Implications: Improved fuel efficiency).
- Since 2010 one large Belgium beam trawler is now using the energy-efficient SumWing as a replacement for standard beam trawl gear. In addition some 25 other beam trawlers are using the SumWing seasonally. Additional there is growing interest in using the electric pulse trawl among the Belgium beam trawl fleet although none of them are using as yet as they are awaiting authorization to do so from the EU. These changes are driven by high fuel prices. (Belgium: Implications: Changes in gear type).
- There have been continued efforts by many countries to reduce fuel costs through the use of more energy efficient gears. Modifications tested in-

clude hydrodynamic/low impact trawl doors, dynex warps, low drag twines and reductions in the size of trawls used. In addition there have been changes in fishing operations through slower steaming to and from grounds, fishing closer to home ports and other fuel saving measures. The actual impacts on fishing effort are difficult to predict but this is likely to be a continuing trend. However, as a result of one project in France (EFFICHALUT) an energy efficient trawl has been developed and is now being used by 15 whitefish trawls. The anticipated annual savings from these 15 vessels is estimated at €800,000 per year. (Multiple countries: Implications: Improved energy efficiency)

- IMR continues to cooperate with a commercial partner (Scantrol AS) on development of a camera-based system to identify and measure individual fish inside a trawl. Preliminary results indicate lengths estimated using the camera system are within 5–10% of manually measured lengths. The system has the potential to be a useful tool to verify size and species stratification by depth during acoustic surveys. A new, more compact, system capable of operating at up to 2000 m depth is being readied for field trials in May and software development to further automate image analysis is underway. (Norway: Implications: New acoustic survey tool).

Technical Conservation Measures

- The Dutch government closed the Botany Gut in December 2011 and 2011 for three months to all trawling to protect cod. The Nephrops fishers have looked for an exemption from this closure on the basis of low cod impact although observer data suggest catches of 2–5/hour Pilot studies will be carried out in 2012 to test selective gears to reduce cod catches. (Netherlands: Implications: Reduction of cod catches).
- At the Dutch Shipyard, Maaskant are developing an on board separator system to sort out debris and benthic organisms before they affect the catch. The objective of this system is to improve the survival rate of discarded flatfish. Trials will be carried out during 2012 and 2013. (Netherlands: Implications: Improved survival of discarded fish).
- In Sweden the use of rigid sorting grids has continued to increase in the Skagerrak and Kattegat. In Skagerrak the use of sorting grid has increased from 50% 2009 to 53% 2010 of total TR2 effort. The TR2 effort is by far the most important gear category in both Skagerrak and Kattegat constituting 80–90% of total effort. Almost 100% have opted to use this device due primarily to national legislation allocating 50% of the total Nephrops quota to grid vessels (Sweden: Implications: Widespread use of sorting grid).
- Extensive testing has been carried out in the North Sea by the UK (Scotland) with a new design of trawl called the Flip-flap netting grid (FFG) which has been developed by a Scottish netmaker for reducing cod catches in the Nephrops fishery. The results show a large and significant decrease in the number of the three main whitefish species retained by the FFG gear. The reductions by weight of cod, haddock and whiting were 73, 67 and 82% respectively. There are indications that will be introduced as a regulated gear across the Scottish fleet during 2012. (UK (Scotland): Implications: Widespread use of selective gear)
- Trials with sorting grids in the Norway pout fishery were completed in 2011, with further tests of flexible grid designs. In 2011 grids with 40mm

bar spacing were made mandatory for Norwegian vessels on the basis of these and earlier trials for blue whiting and Norway pout in the Barents Sea. From mid-2013 all vessels will have to use in these small mesh fisheries in the Norwegian Economic Zone in the North Sea. (Norway: Implications: Mandatory use of sorting grids).

- Experiments from the North Sea carried out by Denmark during 2011 have indicated that 50% of *Nephrops* above MLS are lost through the codend in nominal 120 mm codends used in the North Sea indicated a general increase in mesh size is not applicable in this fishery. (Denmark: Implications: Loss of marketable catch)
- In July 2011 Denmark introduced a mandatory regulation requiring the use of the SELTRA trawl in the demersal fisheries in the Kattegat. This selective device comprises a 180mm square mesh panel or 270mm diamond mesh panel contained in a 4 panel section laced 4m from the codend. This on the basis of trials with this device which showed very good reductions in cod catches. The L50 for the 180mm panel is around 64cm. (Denmark: Implications: Mandatory introduction of a selective gear)

Ecosystem effects

- The large-scale uptake of the pulse trawl has resulted in reduced ecosystem impacts on benthos and also a reduction in discards. A large-scale monitoring programme is currently being undertaken to fully assess these reductions (Netherlands: Implications: Reduced ecosystem impacts in the southern North Sea).
- Several Dutch beam trawlers are testing a new T-Line concept using pins instead of chains to chase fish out of the seabed. The initial trials carried out in December 2011 were not particularly successful as the pins had a tendency to break off and catches of sole were low but a new version will be tested later in 2012. The objective of this design is to reduce fuel and impact on the seabed. (Netherlands: Implications: Lower ecosystem impact of beam trawls).
- Uptake of the Swedish cod and haddock quotas in the Skagerrak have been high in the first two quarters of 2012 (between 55–70%) raising fears that the fisheries will be closed early in the year leading to discarding (Sweden: Implications: Potential discard problem).

Development of New Fisheries

- Two Dutch vessels have converted to potting for crab due to high fuel prices and low returns from other fishing methods. No other details are reported (Netherlands: Implications: Testing of new fisheries).
- The fishery for greater weever (*Trachinus draco*) in the Kattegat seen during 2010 and 2011 as continued. This fishery has developed as a consequence of low catches of *Nephrops* and cod during the first quarter of the year. The weever is also one of few species that are without limiting quotas and few regulations attached to it in the Kattegat. (Sweden: Implications: development of new fishery).

FTFB report to AFWG and NWWG

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Arctic Fisheries areas.

It should be noted that the information contained in this report does not cover fully all fleets engaged in fisheries; information was obtained from Iceland and Norway.

Fleet Dynamics

- In Norway there has not been any removal of fishing effort through decommissioning but the number of vessels has reduced due to movement of quota from newer and bigger vessels. In particular the medium and larger sized seine net fleets are being renewed. Altogether 3–4 new large whitefish trawlers, 4–5 pursers, 7–9 large seine netters and a large number of coastal vessels have entered the fleet over the period 2010–2012. While not measured it is likely that capacity and effort have increased. (Norway: Implications: Increases in fishing effort).
- After several years of low quotas for capelin and blue whiting there has been a large increase in the quota in 2011–2012 which has meant an increase in trawling and purse seining in Iceland. In the capelin fishery this has meant that vessels that were targeting pearlside (*Maurolicous mulleri*) have reverted to capelin. Catches of pearlside have gone from 46,000 tonnes in 2009 to 18,000 tonnes in 2010 to 9,000 tonnes in 2011 to zero in 2012. (Iceland: Implications: Movement from pearlside to capelin).
- During 2010–2011 26 small vessels, 3 factory ships and 1 trawler have entered the Icelandic fleet. There is no indication of vessels having left the fleet. (Iceland: Implications: Increase in fleet).

Technical Creep

- Semi-pelagic trawls for targeting cod and for saithe have been successfully developed and introduced in the Norwegian fishery. The most successful trawl is designed with hexagonal front part meshes and rigged with pelagic trawls off bottom. Better efficiency, less fuel consumption and reduced bottom impact are reported, but currently not quantified. These nets. (Norway: Implications: Increased fuel efficiency and lower bottom impact).
- Research in Norway is looking at the development of prototypes of catch control devices that could help controlling the size of the catch and that gently release the excess of fish at the same fishing depth. The working principle of these prototypes is based on a codend that closes and partially detaches from the rest of the trawl when it has been filled with a certain amount of fish. In this way the fish that is still inside the belly of the trawl have the chance to escape unharmed. Two prototypes, each having a different release mechanism, were developed and tested at sea in April 2011 and March 2012 giving encouraging good results. (Norway: Implications: Better survival of escaping fish).
- Work has begun in Norway to increase the landings of live cod for buffer storage and on-growing, as well as to include small vessels (< 15meter) in this

fishery using the Canadian pair seining technique. A pilot study using a normal bottom seine for pelagic pair seining for haddock gave interesting results. Experiments with pelagic pair seining as well as catch limiting devices for seine nets will continue in 2012/2013. (Norway: Implications: Changes to lower impact gears).

- Up to 12 of the larger seiners in Norway have been converted to freezing at sea. These vessels are trying to target haddock with minimum bycatch of cod to prolong the fishery for haddock and avoid the fishery being closed due to a lack of cod quota. (Norway: Implications: Better utilization of quota).
- Up to 10 vessels in the Icelandic fleet have switched to pair trawling for mackerel and herring from purse seining as this method is felt to be more efficient at catching mackerel in particular. (Iceland: Implications: Switch to more efficient fishing method).
- Around 30 Icelandic vessels are using bottom trawls constructed in T90° net, but with ordinary diamond mesh codends. The reason is to reduce fuel costs and give better durability. Changes in catchability have not been quantified, but fishers believe anecdotally there is increasing catch with these trawls. (Iceland: Implications: More efficient trawls).
- Some Icelandic bottom trawlers and many pelagic trawlers are using Dynex rope warps and many and increasing numbers of pelagic trawlers. An increasing number of bottom trawlers are also switching from using bottom trawls doors to using semi pelagic trawl doors with weights between doors and wing ends. Reason is saving fuel (~10%) and increased durability. (Iceland: Implications: Improved fuel efficiency).

Technical Conservation Measures

- Trials with sorting grids in the Norway pout fishery were completed in 2011, with further tests of flexible grid designs. In 2011 grids with 40mm bar spacing were made mandatory for Norwegian vessels on the basis of these and earlier trials for blue whiting and Norway pout in the Barents Sea. From mid-2013 all vessels will have to use in these small mesh fisheries in the Norwegian Economic Zone in the North Sea. (Norway: Implications: Mandatory use of sorting grids).
- A combined grid device that releases undersized fish and small sized shrimp is being developed in Norway and is being used voluntarily by some vessels fishing shrimp in the Oslofjord. (Norway: Implications: Voluntary uptake of TCM device).
- Full-scale experiments to assess the selectivity of different selection devices have been carried out on board Norwegian vessels in 2010 and 2011. The results showed that the selectivity of a 138 mm T90-codend and that of a codend with 130 mm Exit Windows gives stable and encouraging good selection in midwater trawling for cod. Both codends proved to be effective to sort out small fish under extremely high catch rates of fish (up to 5 tons of fish per minute). Both caught in average less than 2% of undersized fish in areas which had up to 32% of undersized fish. A 55mm sorting grid showed capacity problems at high catch rates. (Norway: Implications: Testing of selective gears).
- Some Norwegian seine net vessels are using 180mm square mesh codends to release all cod below 2.5 kg headed and gutted. The current minimum mesh size is 125mm. This reflects the requirements of the current market requirements. (Norway: Implications: Voluntary increase in selectivity).

- In Iceland two vessels are testing trawls constructed with horizontal separating panels and two codends. The aim is to improve species selectivity and separating species such as Greenland halibut and redfish from cod and haddock. This work will continue in late June this year. (Iceland: Implications: Improved species selectivity).
- There have been closed areas introduced inside several fjords in Iceland for seine nets which have affected a number of smaller vessels. The reasons for these closures are based on ecosystem impacts but the fishers strongly dispute this, claiming such gear to be extremely ecosystem friendly. In addition a ban on directed fisheries for halibut has been introduced that has affecting a number of Icelandic longliners. (Iceland: Implications: Introduction of new closed areas).

Ecosystem Effects

- The development of a pelagic trawl fishery for cod and other gadoids in the Barents Sea will reduce benthic impact significantly. Pelagic trawling is permitted for trawlers that have applied for such a licence. (Pelagic trawling is still illegal north of 65 deg. N. (Norway: Implications: Reduced bottom impact).
- Work has begun in Norway to reduce/avoid the effect of ghost fishing. Development of an intelligent buoy that transmits information (gear, position, owner, dates, etc) to all traffic in the area and a computer program for forecasting deep-water currents (direction, intensity) in the traditional fishing grounds for gillnetting in Norway have recently commenced. The use of available underwater telemetric tracking technology is also being considered to track lost gears as well as the fishing properties of new biodegradable plastic materials in certain parts of the gear (use of PBS monofilaments). (Norway: Implications: Reduction of ghost fishing).
- Trials on a 15m longliner have been continuing in Norway with a new automatic longline hauling system (ALH system). Observations have demonstrated lower losses of fish during hauling reducing unaccounted mortality in this fishery which can be significant. The ALH system also improved work and safety conditions on board the vessel. (Norway: Implications: Reduction in unaccounted mortality).
- Two Norwegian coastal vessels (12 and 15 m) have been used to gather data from gillnet landings of prespawning cod. During these trials the effect on quality (graded by professional crew on the fish plant) as a function of soaking time and type of twines in the gillnets has been studied. It was clearly demonstrated that quality improved with reduced soaking time. In most cases fish were alive when the nets were retrieved after 8 or less hours. A similar effect was found when the nets were changed from mono- to multi-monofilament twines. Despite fish stayed longer alive in the multi-mono twine nets, soaking time still seems to be the most crucial parameter for the quality of gillnet-caught cod during winter (Norway: Implications: Better survival in gillnets).
- A recent analysis of Icelandic catch data has indicated trends in discarding of cod and haddock in the longline, gillnet, seine net and trawl fisheries over the period 2001-2010. For cod discarding has been between 0.5–2%, while for haddock has been between 1–5%. (Iceland: Implications: Very low discarding of cod and haddock).

Development of New Fisheries

- A recent study was carried out in cooperation with a coastal fisher in Malangen fjord (North of Norway) to develop a pot fishery for shrimp. The trials were carried out in June and in the same fishing area where the small coastal vessels regularly trawl. The catch rate of the pots was too low to draw any conclusions on the efficiency of the pots but the results of the study showed that bait conservation is one of the main challenges to establish such a fishery in Norway. Further studies covering different fishing seasons and areas are recommended in the near future. (Norway: Implications: Development of a new fishery with an alternative gear).

FTFB report to WGWIDE, HAWG, WGNEW and WGANSA

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in pelagic fisheries for horse mackerel, mackerel, anchovy, sardine, herring and blue whiting.

It should be noted that the information contained in this report does not cover fully all fleets engaged in pelagic fisheries; information was obtained from Spain and Norway with limited information from several other countries.

Fleet Dynamics

- There are continued indications that Spanish bottom trawlers have varied their spatial-temporal fishing strategy in order to avoid mackerel in their catches, which can be significant at times. This is because of a reduction in the Spanish mackerel quota in 2011 due to an overshoot of the quota in 2010. (Spain: Implications: Reduced bycatch of mackerel).
- As in 2010 the Basque artisanal fleet operating on tuna (trolling lines) and mackerel (handlines) all year, traditional fishing patterns were spread over 8–9 months with about 3–4 months on mackerel and 4–5 months on tuna. The rest of the year the fleet was tied-up. Reductions in the mackerel quota in 2011 has reduced the mackerel season by 1–2 month season for this species and some boats have started fishing with other gears (longlines, gill-nets) to fill out the year activity. (Spain (Basque): Implications: Shift of effort into other fisheries due to quota restrictions).
- National management measures in Spain failed to protect mackerel quotas in 2010 (ARM/271/2010) and as a result the quota was exceeded by 79% and a reduction in the Spanish mackerel quota for 2011. This has led to an early closure of the fishery (3–5 March for purse-seine and trawl fleets respectively) in 2011. This has affected a large number of vessels with significant reductions in effort. (Spain: Implications: Reduction in effort in mackerel fisheries).
- About 20% of the artisanal fleet in the Basque region of Spain operating with trolling lines for tuna and handlines for mackerel are planning to decommission their vessels in 2012. This is due primarily to the reduction in mackerel quota as a result of the overshoot in quota in 2010 (Spain: Implications: reduction in fleet size).

- The Basque trolling and handline fleet in VIIIc have also started to look for other alternatives of diversification driven by mackerel quota reduction, some have diversified to longlines and purse-seines all them in VIIIc (Spain: Implications: Shift of effort into other fisheries).
- In Norway there has not been any removal of fishing effort through de-commissioning but the number of vessels has reduced due to movement of quota from newer and bigger vessels. In particular the medium and larger sized seine net fleets are being renewed. Altogether 3–4 new large white-fish trawlers, 4–5 pursers, 7–9 large seine netters and a large number of coastal vessels have entered the fleet over the period 2010–2012. While not measured it is likely that capacity and effort have increased. (Norway: Implications: Increases in fishing effort).

Technical Creep

- There have been repeated attempts by the Basque fleets to reduce operating costs by diversifying into other fisheries but with only limited success. Driven by the reduction in the mackerel quota this has been extended to the trolling and handline fleets that have diversified into longlines and purse-seines fisheries in ICES Area VIIIc. (Spain (Basque): Implications: Diversification).
- Up to 10 vessels in the Icelandic fleet have switched to pair trawling for mackerel and herring from purse seining as this method is felt to be more efficient at catching mackerel in particular. (Iceland: Implications: Switch to more efficient fishing method).
- Research in Norway is looking at the development of prototypes of catch control devices that could help controlling the size of the catch and that gently release the excess of fish at the same fishing depth. The working principle of these prototypes is based on a codend that closes and partially detaches from the rest of the trawl when it has been filled with a certain amount of fish. In this way the fish that is still inside the belly of the trawl have the chance to escape unharmed. Two prototypes, each having a different release mechanism, were developed and tested at sea in April 2011 and March 2012 giving encouraging good results. (Norway: Implications: Better survival of escaping fish).
- Research in Norway is looking at the development of prototypes of catch control devices that could help controlling the size of the catch and that gently release the excess of fish at the same fishing depth. The working principle of these prototypes is based on a codend that closes and partially detaches from the rest of the trawl when it has been filled with a certain amount of fish. In this way the fish that is still inside the belly of the trawl have the chance to escape unharmed. Two prototypes, each having a different release mechanism, were developed and tested at sea in April 2011 and March 2012 giving encouraging good results. (Norway: Implications: Better survival of escaping fish).

Technical Conservation Measures

- In the Basque artisanal fleets daily or weekly quotas (depending on the fishery) have been introduced by the fishers voluntarily in mackerel fishery (handliners and purse-seiners) and in the anchovy fishery (purse-seiners). This is mainly driven by higher market prices for better quality

landed product but also by restrictive quotas in both fisheries. All vessels in these fisheries are complying with these measures (Spain (Basque) Implications: Voluntary quotas limits introduced).

- Gear technologists, commercial trawl designers and researchers responsible for pelagic fish stock assessment in Norway, Iceland and Faroe Island have agreed on a common design of a pelagic trawl, and how it should be operated during surveys for the mackerel stock in the Norwegian Sea. The trawl design was refined in a process where all partners were involved. In 2012 the three Nordic countries will utilize the Multpelt 832 trawl and the agreed trawling strategy to estimate the mackerel stock with a swept-area method. The pelagic trawl has a circumference of 832 m in the entrance, having 16 m in the front part decreasing to 60 mm in the codend. While surface trawling for mackerel 350 m of Dyneema warp rope is used in front of the trawl doors, and towing speed is generally 5 kn. Bridle lengths are 80 m. (Norway, Iceland and Faroe Islands: Implications: New survey trawl design).
- In 2011 work in Norway continued on methods to get samples of purse-seine caught fish on deck in an early stage in the purse seining process, and well before crowding. Net pockets, both natural and pockets sewn onto the net wall of the purse-seine gave samples, but not on a regular basis. An extreme pocket with an opening area of five by five meter of transparent polyamide netting was thought to fake a hole in the net wall, but video observation demonstrated that the herring did not interpret this "invisible" netting as a hole. In cooperation with the fishing industry, different parts of the end of the purse-seine ("bunt") are now being modified; mostly to secure that pelagic fish easily can be slipped from purse-seine in case of too big catches or due to wrong size or quality. Well proven technique from the days of live fishing and storage of sprat and mackerel is being revived and incorporated in the purse-seine used for pelagic species. (Norway: Implications: Improved survival of slipped fish).
- Under a French project Target-strength measurements for anchovy and sardine have been collected using a towed body "EROC" and an open pelagic trawl termed "ENROL". Up to these measurements no accurate Target Strength values existed for these species. (France: Implications: Improved survey techniques).
- In order to manage the newly developed boarfish fishery in addition to the TAC Ireland has introduced seasonal closures; from 1 September –31 October ICES (area VIIg) to protect herring feeding and prespawning aggregations and from 15 March – 31 August where mackerel are frequently encountered as a large bycatch. A catch rule ceiling of 5% bycatch was also implemented within the fishery where boarfish are taken with other TAC controlled species. (Ireland: Implications: Management of boarfish fishery).

Ecosystem Effects

- Basque: During the beginning of 2011 national regulation forbidden mackerel catch to all the national fleets till the 15th of February. The trawl fleet operating in ICES VIIIc and usually fishing mackerel at the beginning of the year was obliged to discard great quantities of mackerel because in that season mackerel is abundant in the areas where this fleet operates. At the beginning of 2011 the trawl fleet operating in ICES VIIIc discarded large

quantities of mackerel due to high abundant in the areas were this fleet operates but no quota entitlements (Spain (Basque): Implications: High discarding of mackerel).

- Full-scale survival experiments were carried out with Norwegian spring-spawning herring at the southwest coast of Norway in March 2011 and 2012. Herring were caught with purse-seines and carefully transferred to four large holding pens without breaking up the natural schooling behaviour. One pen was kept as control, while the fish in the three other pens were crowded to different densities for 10 minutes. Three replicate crowding experiments were carried out. The results showed that the mortality of herring (*Clupea harengus*) after exposure to heavy crowding and subsequent slipping from purse-seines may be unacceptably high. The mortality rate five days after slipping was proportional to crowding density, reaching 36% in the hardest crowded group. The mortality rates in the control groups varied between 1.1 and 4.5%. These results shows that slipping after hard crowding should not be allowed as a means to regulate herring catches, and suggest a need to revise the legislation on slipping in these fisheries. However, the experiments also showed that herring may survive slipping from purse-seines well if handled gently and released at an early stage of pursing. (Norway: Implications: Survival rate of discarded fish).

FTFB report to WGMME, SGBYC, WGECO and WGNEW

Ecosystem Effects

- As reported in previous years from Ireland and the UK predation of fish catches by mainly Grey seals form gillnet/tanglenet fisheries continues to be a problem on all coasts of the UK and Ireland. Many inshore fishers have now stopped gillnetting as the level of damage is so high. A current Irish study is currently assessing the level of seal depredation in inshore fisheries around Ireland and has reported some seal bycatch along with depredation. This study is due to be completed in 2012. (Ireland and UK: Implications: Increased predation by seals).
- Observer programmes in the Irish pelagic trawl fisheries (mackerel, horse mackerel, blue whiting, herring, and albacore tuna) implemented since 2005 have shown cetacean bycatch in these fisheries to be virtually non-existent. Only a bycatch has been observed in the tuna fishery and none at all in the last 2 years (Ireland: Implications: Low cetacean bycatch).
- The UK has being testing an acoustic deterrent device (DDD-O3L) which has proved highly effective in reducing bycatch in the >12m gillnet fisheries in ICES division VII (e, f, g, h and j). The UK authorities are planning to make the use of this device mandatory in these fisheries. (UK: Implications: Reductions in cetacean bycatch).
- A French consortium including the netmaker Le Drezen, the National Museum of Natural History, Ifremer and CNRS and the French Southern and Antarctic Lands (TAAF) launch ORCASAV campaign have begun experimental fishing trials for toothfish. These trials aim to test the effectiveness of the trap fishery, which could be an alternative or at least an extension to longlines from which orcas and sperm whales have learned to predate from creating a serious economic and ecological problem. The results have

demonstrated that these traps are feasible in this fishery. (France: Implications: Limiting depredation)

- An Italian project is evaluating mitigation measures to reduce the bycatch of protected species in pelagic trawl fisheries in the Adriatic Sea targeting small pelagic species (Anchovy and Sardine). Following observation work the trials have concentrated on using a modified TED (*Turtle Excluder Device*) adapted to a single boat pelagic trawl. The preliminary results are encouraging. Next step will be to test the TED in a pair trawl which is the main activity in the Adriatic Sea. (Italy: Implications: Testing of mitigation device).
- A modified scallop dredge (N-VIRO) was tested against a standard tooth bar dredge on the southeast and west coast of Ireland. The results of these trials suggested the N-VIRO dredge to be more fuel efficient with less benthic impact and less damage to scallop. There was no reduction in catches associated with this dredge (Ireland: Implications: Low impact scallop dredge).
- Full-scale survival experiments were carried out with Norwegian spring-spawning herring at the southwest coast of Norway in March 2011 and 2012. Herring were caught with purse-seines and carefully transferred to four large holding pens without breaking up the natural schooling behaviour. One pen was kept as control, while the fish in the three other pens were crowded to different densities for 10 minutes. Three replicate crowding experiments were carried out. The results showed that the mortality of herring (*Clupea harengus*) after exposure to heavy crowding and subsequent slipping from purse-seines may be unacceptably high. The mortality rate five days after slipping was proportional to crowding density, reaching 36% in the hardest crowded group. The mortality rates in the control groups varied between 1.1 and 4.5%. These results shows that slipping after hard crowding should not be allowed as a means to regulate herring catches, and suggest a need to revise the legislation on slipping in these fisheries. However, the experiments also showed that herring may survive slipping from purse-seines well if handled gently and released at an early stage of pursing. (Norway: Implications: Survival rate of discarded fish).
- Work has begun in Norway to reduce/avoid the effect of ghost fishing. Development of an intelligent buoy that transmits information (gear, position, owner, dates, etc) to all traffic in the area and a computer program for forecasting deep-water currents (direction, intensity) in the traditional fishing grounds for gillnetting in Norway have recently commenced. The use of available underwater telemetric tracking technology is also being considered to track lost gears as well as the fishing properties of new biodegradable plastic materials in certain parts of the gear (use of PBS monofilaments). (Norway: Implications: Reduction of ghost fishing).
- Trials on a 15m longliner have been continuing in Norway with a new automatic longline hauling system (ALH system). Observations have demonstrated lower losses of fish during hauling reducing unaccounted mortality in this fishery which can be significant. The ALH system also improved work and safety conditions on board the vessel. (Norway: Implications: Reduction in unaccounted mortality).
- Two Norwegian coastal vessels (12 and 15 m) have been used to gather data from gillnet landings of prespawning cod. During these trials the ef-

fect on quality (graded by professional crew on the fish plant) as a function of soaking time and type of twines in the gillnets has been studied. It was clearly demonstrated that quality improved with reduced soaking time. In most cases fish were alive when the nets were retrieved after 8 or less hours. A similar effect was found when the nets were changed from mono- to multi-monofilament twines. Despite fish stayed longer alive in the multi-mono twine nets, soaking time still seems to be the most crucial parameter for the quality of gillnet-caught cod during winter (Norway: Implications: Better survival in gillnets).

- The large-scale uptake of the pulse trawl has resulted in reduced ecosystem impacts on benthos and also a reduction in discards. A large-scale monitoring programme is currently being undertaken to fully assess these reductions (Netherlands: Implications: Reduced ecosystem impacts in the southern North Sea).
- Several Dutch beam trawlers are testing a new T-Line concept using pins instead of chains to chase fish out of the seabed. The initial trials carried out in December 2011 were not particularly successful as the pins had a tendency to break off and catches of sole were low but a new version will be tested later in 2012. The objective of this design is to reduce fuel and impact on the seabed. (Netherlands: Implications: Lower ecosystem impact of beam trawls).
- At the Dutch Shipyard, Maaskant are developing an on board separator system to sort out debris and benthic organisms before they affect the catch. The objective of this system is to improve the survival rate of discarded flatfish. Trials will be carried out during 2012 and 2013. (Netherlands: Implications: Improved survival of discarded fish).

Development of New Fisheries

- The fishery for greater weever (*Trachinus draco*) in the Kattegat seen during 2010 and 2011 as continued. This fishery has developed as a consequence of low catches of *Nephrops* and cod during the first quarter of the year. The weever is also one of few species that are without limiting quotas and few regulations attached to it in the Kattegat. (Sweden: Implications: development of new fishery).
- After several years of low quotas for capelin and blue whiting there has been a large increase in the quota in 2011–2012 which has meant an increase in trawling and purse seining in Iceland. In the capelin fishery this has meant that vessels that were targeting pearlside (*Maurolicous mulleri*) have reverted to capelin. Catches of pearlside have gone from 46,000 tonnes in 2009 to 18,000 tonnes in 2010 to 9,000 tonnes in 2011 to zero in 2012. (Iceland: Implications: Movement from pearlside to capelin).

FTFB report to GFCM

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Mediterranean Sea.

It should be noted that the information contained in this report does not cover fully all fleets engaged in fisheries; information was obtained from Italy only.

Fleet dynamics

- As a result of measures under Regulation (EC) 1967/2006 from June 2010 in the Northern Adriatic Sea the use of towed gears has been prohibited within 3 nautical miles from the coast while the use of beach-seine and boat seine targeting *Aphia minuta* (Gobiidae) and juveniles of sardine (*Sardina pilchardus*) is prohibited without a specific management plan. This affects a large number of Italian vessels and is shifting effort into other fisheries and other areas (Italy: Implications: Shifts in effort as a result of management changes).
- A derogation to the above measures has been introduced in January 2011 whereby the use of trawlnets between 0.7 and 1.5 nautical miles off the coast (at a depth greater than 50 m) is authorized in the following Regions: Liguria, Sicilia, Calabria. (Italy: Implications: Unknown).
- Following the adoption of an Italian Ministerial decree since 2009 bottom trawlers using twin trawls are obliged to fishing one day less a week than single rig trawlers. (Italy: Implications: Reduction in effort using twin-rigs).
- In 2011 some fishing vessels change their activity from rapido trawl to midwater pelagic trawl and from midwater pelagic trawl to bottom trawl. This is mainly for economic reasons. (Italy: Implications: Shifts in effort between métiers).
- In order to reduce fishing effort, in the last years some local fisheries have voluntarily reduced their fishing time from 5 days (legal limit) to 3.5 days. This is mainly for economic reasons. (Italy: Implications: Reduction in effort).
- Several Italian pairtrawlers have switched to single boat trawling in the central Adriatic to reduce fuel costs, manage their own operating costs independently of another vessel and also allow more freedom to adapt their fishing strategy. (Italy: Implications: Shift from pair trawling to single boat trawling).

Technical Creep

- In the last 3–4 years some Italian bottom trawlers of the central-northern Adriatic, switched their activity from single to twin-rig trawling (named by the Italian fishers: “Rete gemella”). The main characteristic of the twin-rig are four-panel trawls with small or large lateral panels (named Americana trawl, in Italian). These nets also have large meshes in the wing section and are manufactured in Raschel knotless-PA and knotted-PE netting.

The nets are designed to have increased vertical and horizontal openings are thought to be highly efficient. (Italy: Implications: More efficient trawls).

- Some Italian fishing vessels using the rapido trawl (multi-rig trawl) have decreased the width of the beam from 4 to 3–3.5 m in order to decrease bottom contact and fuel consumption (Italy: Implications: Improved fuel efficiency).

Technical Conservation Measures

- In order to reduce mortality rates for juveniles and discards of dying marine organisms by fishing vessels, Council Regulation (EC) No 1967/2006, concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean, establishes that “...from 1 July 2008, the net referred to in point 1 (that is “towed nets”) shall be replaced by a square-meshed net of 40 mm at the codend or, at the duly justified request of the shipowner, by a diamond meshed net of 50 mm”. Italian fishers were not prepared for this change and most of them, particularly in the South of Italy still do not accept the modification from the traditional mesh size. The fishing fleet of central-northern Italian seas are more collaborative, but they do not accept the square mesh and use the 50mm diamond mesh size codend (Italy: Implications: Poor selectivity).
- There is widespread misinterpretation of certain technical measures among Italian fishers leading to limited impact of new rules introduced. Given that the length of the codend is not well defined, the fishers have adopted to use shorter netting panel (about 50–100 cm) at the final part of the codends with legal mesh size, leaving the rest of the net unchanged (smaller mesh size). In addition the measurement of codend circumference remains largely unchecked by fishery inspectors. Overall the technical changes introduced Under Regulation (EC) 1967/2006 remain ineffective. (Italy: Implications: Poor implementation of technical measures regulations).
- In Spain, several studies have been carried out in Mediterranean waters. In the Balearic Islands, a change from 40 mm diamond-shaped mesh to a 40 mm square-shaped mesh resulted in changes in the selectivity parameters (L50) and a reduction in the biomass discarded. The entire Spanish fleet has now adopted this new mesh size (Spain: Implications: Increased selectivity).

Ecosystem Effects

- Some Italian fishers in the central Adriatic Sea operating with demersal and pelagic trawl, on a voluntary basis have started to use pingers as deterrent for dolphin. They believe these devices will reduce predation and hence increase the efficiency of their gear. (Italy: Implications: Possible reduction in cetacean bycatch).
- Some Italian fishers have introduced a window into the lower panel of bottom trawls in order to reduce the catch of shellfish, sea urchin, stones but this is countered by fishers increasing the number and weights of tickler chains and the weight of groundropes (Italy: Implications: Unknown).

Annex 6: A Partial Global Summary of the Fisheries Using Artificial Light

Fishing gear [Boat size]	Target species	Light source	Power	Placement	Month	Landings (tonnes)	Region
Squid Jigging	Squids	Metal Halide (MH) Lamps+ Halogen or LED+MH lamps	Max. 250 kW	Surface		In 2010	
[30-138 GRT and 139-500 GRT]	<i>Todarodes pacificus</i>				May-Feb. in Japan Sea	35743 t	Japan Sea
	<i>Ommastrephes bartrami</i>			(U/W is used for <i>O. bartrami</i> in daytime to lead squid to upper	May-Aug. in Pacific	5350 t	Pacific ocean
	<i>Loligo bleekeri</i>				June-Nov. in East China Sea	Others 521 t	East China Sea
Squid Jigging	Squids					<u>In 2010</u>	
[< 19 GRT]	<i>Todarodes pacificus</i>	MH lamp + Halogen	Max. 180 kW for 19 GRT Typically 60 kW for <10 GRT	Surface	All season	69046 t	Japan Sea
	<i>Photololigo edulis</i>	MH lamp + LED + Halogen				11 t	Pacific coast of Japan
	<i>Loligo bleekeri</i>					Others 12595 t	East China Sea
Squid Jigging	Squids	MH lamp + Halogen	Max. 250 kW	Surface	All season	No data	New Zealand EEZ
(only 2 Japanese boats) [139-500 GRT]	New Zealand southern arrow squid, <i>Nototodarus sloanii</i>			(U/W (5 kW x 2 bulbs) are used in daytime to activate squid			
Squid Jigging [139-500 GRT] (only 4 Japanese boats)	Humboldt squid <i>Dosidicus gigas</i>	MH lamp + Halogen	Max. 300 kW	Surface (U/W lamp not used because of squid attack)	All season	No data	Peru EEZ

[illegible]

[illegible]

Fishing gear [Boat size]	Target species	Light source	Power	Placement	Month	Landings (tonnes)	Region
Scoop net	Anchovy (<i>Engraulis japonica</i>)	Incandescent (halogen) lamp	Various; Typically 0.5- 1 kW/bulb	Surface lamp+(U/W lamp)	various	No data	Coastal area in western Japan
Scoop net/jigging	Mackerel (<i>Scombridae</i>)	Incandescent (halogen) lamp	?	Surface lamp	All season	No data	North Pacific coast of Japan
Scoop net	Juvenile of eel (<i>Anguilla japonica</i>)	Incandescent (halogen) lamp	?	Surface lamp	Feb.-March	In 2010 9.2 t	Japan
Gillnet (driftnet) 2 types; 1 for attraction and 1 for herding	Silver-stripe round herring (<i>Spratelloides gracilis</i>)	Incandescent (halogen) lamp	<12 kW	Surface and U/W lamps	Aug.-Feb.	No data	Southwestern Japan
Handline	Chicken grant (<i>Parapristipoma trilineatum</i>)	Incandescent lamp	1-3 kW	Surface + U/W lamp	June-Oct.	No data	Coastal area in western Japan
cast net, stick- held dip net, stick- cast net and stick held box net	Cephalopods: L. duvauceli, L. <i>Sepioteuthis lessoniana</i> and <i>Sepia aculeata</i>	Incandescent bulbs including two red spot-lights	17 kW	Surface	No data	No data	Gulf of Thailand
Purse seine	Omena (<i>Rastrineobola argentea</i>)	Kerosene lamp		Surface lamp	Sept.-March	No data	Lake Victoria, Africa

Fishing gear [Boat size]	Target species	Light source	Power	Placement	Month	Landings (tonnes)	Region
Jigging	Japanese flying squid (<i>Todarodes pacificus</i>)	Metal Halide Lamp + Halogen (few)	60-141 kW	Surface lamp	Feb - Dec	Squid 48,000	Korea
	Hairtail (<i>Trichiurus lepturus</i>)					Hairtail 9,000	
Purse Seine	Chub mackerel (<i>Scomber japonicas</i>)	Metal Halide Lamp	S-210 (1.5kW)	Surface and Underwater lamp	Jan - Dec	Chub mackerel 90,000	Korea
	Japanese Anchovy (<i>Engraulis japonicas</i>)		UW-50 (2-5 kW)			Anchovy 28,000	
Anchovy scoop net	Japanese Anchovy (<i>Engraulis japonicas</i>)	Incandescent Lamp, LED Lamp	1 kW	Surface lamp	Feb - Jun	Anchovy 6,000	Korea
Stick-held dip net	Saury	Incandescent Lamp or LED Lamp Search light	289-317 kW 5-6 kW	Surface lamp	Aug - Dec	?	Korea
Lever lift net	Japanese anchovy (<i>Engraulis japonicas</i>)	Incandescent Lamp, Metal Halide Lamp	2x2 kW	Surface lamp	Jun - Dec	Anchovy 6,000	Korea
	Calamary, Yariika (<i>Loligo bleekeri</i>)	Metal Halide Lamp	30 kW		Feb - Apr		

Fishing gear [Boat size]	Target species	Light source	Power	Placement	Month	Landings (tonnes)	Region
Luring Purse Seine	Sardine, Mackerel, Scad, Herring	Gas Lamp 3 pcs x 2	?	Surface floating			Malaysia (1995)
Purse Seine	Indian mackerel, Hardtail scad, Bonito	Pressure kerosene lamps - Main boat lamp - Auxiliary boat lamp	?	Surface lamp			Malaysia (1995)
Purse Seine	Mackerel, Scad, Trevally	Fluorescent lamps on a raft	60W –DC 12V	Surface floating lamp			Malaysia (1995)
Squid cast net	Squid	500Wx13 & 2 red spot lights	6.5kW	Surface lamp			Malaysia (1995)
Stick-held cast net	Squid	500Wx22 & 2 red spot lights	6kW	Surface lamp			Malaysia (1995)
Purse Seine (with 3-5 light boat)	Mackerel	Incandescent Lamp	S-10-12 (1kW)	Surface lamp	?		Philippines (2003)
	Sardine	Halogen Lamp	s-6-10 (1-5kW)				
Purse Seine	anchovy	Incandescent Lamp 1kW		Surface lamp	?		Philippines (2003)
Scoop net	anchovy	?	?	Surface lamp			Philippines (2003)
Jigging (Mother boat + 13-18 bamboo boat)	Flying squid	A system of flashing lights	?	Surface lamp			Vietnam (2002)
Stick-Held Dip net	Anchovy	-	5 kW				Vietnam (2002)
Stick-Held Falling net	Squid	Lamp 18 x 500 W	9 kW	Surface lamp			Vietnam (2002)

Fishing gear [Boat size]	Target species	Light source	Power	Placement	Month	Landings (tonnes)	Region
Purse seine	Sprat (<i>Sprattus sprattus</i>)	Gas lamp	12-15 kW	Surface lamp	08.okt	3 500 (90-100%)	Norway, North Sea coast
Purse seine	Norwegian spring spawning herring (<i>Clupea harengus</i>)	Gas lamp	12-15 kW	Surface lamp	03.apr	335 200 (ca. 100%)	North Sea coast
Purse seine	Mackerel (<i>Scomber scombrus</i>)	Gas lamp	12-15 kW	Surface lamp	05.okt	42 300 (ca. 70%)	North Sea coast
Purse seine	Saithe (<i>Pollachius virens</i>)	Gas lamp	12-15 kW	Surface lamp	04.des	?	North Sea coast
Purse seine	Sardine (<i>Sardina pilchardus</i>) Anchovy (<i>Engraulis encrasicolus</i>)	Incandescent lamp	mean 38 amp	Surface lamp	Mar-Oct	?	Mediterranean, France
Purse Seine	Anchovy (<i>Engraulis encrasicolus</i>) Mackerel (<i>Scomber scombrus</i>) Bogue (<i>Boops boops</i>) Sardine (<i>Sardina pilchardus</i>)	Incandescent Lamp	8000 W	Surface lamp	01 September-15 April	???	Turkey, Mediterranean and Aegean Sea

Annex 7: Bibliography for Use of Artificial Light in Fisheries

- Abrahamsen, M. B., Browman, H. I., Fields, D. M., and Skiftesvik, A. B. 2010. The three-dimensional prey field of the northern krill, *Meganyctiphanes norvegica*, and the escape responses of their copepod prey. *Marine Biology*, 157(6): 1251–1258. doi:10.1007/s00227-010-1405-9.
- Ae, B.-Seong B., Ark, B.-Jae P., Eong, E.-Cheol J., Ang, Y.-Su Y., and Ark, H.-Hoon P. 2009. Design and performance evaluation of fish-luring system using the air-cooled LED lamp for jigging and angling boat. *J. Kor. Soc. Fish. Tech.*, 45(2): 85–95. doi:10.3796/KSFT.2009.45.2.85
- Aksnes, D.L., Utne, A. C. 1997. A revised model of visual range in fish. *Sarsia*, 82: 137–147.
- Amaral, E. H., and Carr, H. A. 1980. Experimental Fishing for Squid with Lights in Nantucket Sound. *Marine Fisheries Review*, 42(7–8): 51–56.
- An, H. C., and Choo, H. D. 1993. Fishing efficiency of squid jigging in relation to the variation of fishing lamp power (abstract only). *Bull. Natl. Fish. Res. Dev. Agency Korea*, 48: 179–186.
- An, Y.-I., Jeong, H.-G., and Jung, B.-M. 2009. Behavioral reaction of common squid *Todarodes pacificus* to different colors of LED Light. *Bulletin of the Korean society of Fisheries Technology*, 45(3): 135–143. doi:10.3796/KSFT.2009.45.3.135
- Anthony, P. D. 1981. Visual contrast thresholds in the Cod *Gadus morhua* L (scan - ikke søk-bar).pdf. *Journal of Fish Biology*, 19: 87–103.
- Arakawa, H., Choi, S., Arimoto, T., and Nakamura, Y. 1996a. Underwater Irradiance Distribution of Fishing Lights Used by Small-type Squid Jigging Boat. *Nippon Suisan Gakkaishi*, 62(3): 420–427.
- Arakawa, H., Choi, S., Arimoto, T., and Nakamura, Y. 1996b. Underwater irradiance distribution of fishing lights used by small-type squid jigging boat (abstract only). *Nippon Suisan Gakkaishi*, 62(3): 420–427.
- Arakawa, H., Choi, S., Arimoto, T., Nakamura, Y. 1998. Relationship between Underwater Irradiance and Distribution of Japanese Common Squid under Fishing Lights of a Squid Jigging Boat. *Fisheries Science*, 64(4): 553–557.
- Arimoto, T., Glass, C. W., and Zhang, X. 2011. Fish Vision and Its Role in Fish Capture. In: Pingguo He (Ed.), *Behaviour of Marine Fish: Capture Processes & Conservation Challenges* (pp. 25–43).
- Bae, B.-S., An, H.-C., Kwon, K.-J., Park, S.-W., Park, C.-D., and Lee, K.-H. 2011. Design and performance estimation of fish-luring system using the water cooling typed LED lamp. *Bulletin of the Korean society of Fisheries Technology*, 47(2): 79–87. doi:10.3796/KSFT.2011.47.2.079
- Bae, B.-S., Jeong, E.-C., Park, H.-H., Chang, D.-S., and Yang, Y.-S. 2008a. Behavioral characteristic of Japanese flying squid, *Todarodes pacificus* to LED light. *Bulletin of the Korean society of Fisheries Technology*, 44(4): 294–303. doi:10.3796/KSFT.2008.44.4.294
- Bae, B.-S., Jeong, E.-C., Park, H.-H., Chang, D.-S., and Yang, Y.-S. 2008b. Behavioral characteristic of Japanese flying squid, *Todarodes pacificus* to LED light. *Bulletin of the Korean society of Fisheries Technology*, 44(4): 294–303. doi:10.3796/KSFT.2008.44.4.294
- Batty, R. S., Blaxter, J. H. S., and Richard, J. M. 1990. Light intensity and the feeding behaviour of herring, *Clupea harengus*. *Marine Biology*, 107: 383–388.
- Beaudeau, J.-L. 2008. [A word from the editor]. *Annales de biologie clinique*, 66(1): 5. doi:10.1684/abc.2008.0200
- Ben Yami, M. 1976. *Fishing with Light* (p. 121). FAO.
- Ben Yami, M. 1988. Attracting fish with light. FAO.

Brill *et al.*, 2001 ##

Calise, L. 2009. *Multifrequency acoustic target strength of Northern krill*. University of Bergen. Retrieved from <http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Multifrequency+acoustic+target+strength+of+Northern+krill#0>

Casey, J. M., and Myers, R. A. 1998. Diel variation in trawl catchability: is it as clear as day and night? *Canadian Journal of Fisheries and Aquatic Sciences*, 55(10): 2329–2340. doi:10.1139/cjfas-55-10-2329

Chancey, A. M. 2005. Short range underwater optical communication links. *MSc Thesis, North Carolina State University*, 104.

Choi, S. 2006. Radiation and underwater Transmission characteristics of a High-luminance LED as the Light source for fishing lamps. *J. Kor. Fish. Soc.*, 39(6): 480–486.

Choi, S. 2002. Relationship between the boat sizes, light source output for fishing lamps and the catch of squid, *Todarodes pacificus* Steenstrup, in coastal squid jigging fishery of Japan. *J. Kor. Fish. Soc.*, 35(6): 644–653.

Choi, S. J. 2002. Relationship between the boat sizes, Light source output for fishing Lamps and the catch of squid o coastal squid jigging fishery of japan. *J. Kor. Fish. Soc.*, 35(6): 644–653.

Choi, S. J. 2009. Characteristics of Spectral Irradiance Based on the Distance from the Light Source and Operating Method for Fishing Lamps with a Combined Light Source. *Kor. J. Fish. Aquat. Sci.*, 42(6): 711–720.

Choi, S. J., and Arakawa, H. 2001. Relationship between the catch of squid. According to the Jigging Depth of Hooks and underwater Illumination in squid Jigging Boat. *J. Kor. Fish. Soc.*, 34(6): 624–631.

Choi, S. J., Arakawa, H., Arimoto, T., and Nakamura, Y. 2003. Underwater illuminance of line light source model for fishing lamps of coastal squid jigging boats. *Nippon Suisan Gakkaishi*, 69(1): 44–51.

Choi, S., Arakawa, H. 2001. Relationship between the catch of squid, *Todarodes pacificus* Steenstrup, according to the jigging depth of hooks and underwater illumination in squid jigging boat. *J. Kor. Fish. Soc.*, 34(6): 624–631.

Choi, Sok Jin, Nakamura, Y., and Arimoto, T. 1997. Horizontal Illuminance of Line Source Model for Fishing Lamps around the Coastal Squid Jigging Boats. *Nippon Suisan Gakkaishi*, 63(2): 160–165.

Clarke, M. R., and Pascoe, P. L. 1998. The influence of an electric light on the capture of oceanic cephalopods by midwater trawl. *J. Mar. Biol. Ass. UK*, 78: 561–575.

Clarke, M.R., Pascoe, P. L., and Maddock, L. (1986). Influence of 70 watt electric lights on the capture of fish by otter trawl off Plymouth. *J. Mar. Biol. Ass. UK*, 66: 711–720.

Clarke, Malcolm R., and Pascoe, L. 1985. The Influence Of An Electric Light On The Capture Of Deep-Sea Animals By A Midwater Trawl possible method of increasing the catch of research trawls used in the deep sea. *J. Mar. Biol. Ass. UK*, 65: 373–393.

Clarke, M. R., Pascoe, P. L. 1985. The influence of an electric light on the capture of deep-sea animals by a midwater trawl (scan - ikke søkbar).pdf. *J. Mar. Biol. Ass. UK*, 65: 373–393.

Cole, R. G., Alcock, N. K., Tovey, A., and Handley, S. J. 2004. Measuring efficiency and predicting optimal set durations of pots for blue cod *Parapercis colias*. *Fisheries Research*, 67(2): 163–170. doi:10.1016/j.fishres.2003.09.039

Coutant, C. C. 2001. Coutant 2001 guidance system.pdf. *American Fisheries Society Symposium*, 26: 105–113.

- Cui, G., Wardle, C. S., Glass, C. W., Johnstone, A. D. F., Mojsiewicz, W. R. 1991. Light level thresholds for visual reaction of mackerel, *Scomber scombrus*, to coloured monofilament nylon gillnet materials. *Fisheries Research*, 10: 255–263.
- Dalpadado, P., Ellertsen, B., Melle, W., and Skjoldal, H. R. 1998. Summer distribution patterns and biomass estimates of macrozooplankton and micronekton in the Nordic seas. *Sarsia*, 83: 103–116.
- Denys, C. J., and Brown, P. K. 1982. Euphausiid Visual Pigments. *J. Gen. Physiol.*, 80(September): 451–472.
- Doherty, P. J. 1987. Light-traps selective but useful devices for quantifying the distributions and abundances of larval fish (scan - ikke søkbar).pdf. *Bulletin of Marine Science*, 41(2): 423–431.
- Engås, A., Haugland, E. K., and Øvredal, J. T. 1998. Reactions of cod (*Gadus morhua* L.) in the pre-vessel zone to an approaching trawler under different light conditions Preliminary results. *Hydrobiologia*, 371/372: 199–206.
- Eriksen, E., and Dalpadado, P. 2011. Long-term changes in Krill biomass and distribution in the Barents Sea: are the changes mainly related to capelin stock size and temperature conditions? *Polar Biology*, 34(9): 1399–1409. doi:10.1007/s00300-011-0995-0
- Feist, B. E., and Anderson, J. J. 1991. Review of Fish Behavior Relevant to Fish Guidance Systems. *Fisheries (Bethesda)*. University of Washington.
- Frank, T. M., and Case, J. 1988. Visual spectral sensitivities of bioluminescent deep-sea crustaceans. *The Biological Bulletin*, 175, 261–273. Retrieved from <http://www.biolbull.org/content/175/2/261.short>
- Fritsches, K. A., Marshall, N. J., and Warrant, E. J. 2003. Retinal specializations in the blue marlin: eyes designed for sensitivity to low light levels. *Marine and Freshwater Research*, 54(4): 333–341. CSIRO. Retrieved from <http://www.publish.csiro.au/?paper=MF02126>
- Fritsches, K. A., Brill, R. W., and Warrant, E. J. 2005. Warm Eyes Provide Superior Vision in Swordfish. *Current Biology*, 15(1): 55–58. Retrieved from <http://www.sciencedirect.com/science/article/pii/S0960982204009960>
- Fritsches, K. A. 2006. Game Fish Vision. *Blue Water*. 58: 73–77.
- Fujiyasu, H. et al. 2008. LED and semiconductor photo-effects on living things.pdf. *J. Light & Vis. Env.*, 32(2): 222–225.
- Gabr, M., Fujimori, Y., Shimizu, S., and Miura, T. 2007. Trawling experiment in a circular water tank to assess the effects of towing speed, light intensity, and mesh shape on active escape of undersized fish. *Fisheries Science*, 73(3): 557–564. doi:10.1111/j.1444-2906.2007.01368.x
- Gabriel, O., Lange, K. Dahm, E. and Wendt, T. 2005. Fishing Catching Methods of the World. 4th ed. Blackwell Publishing, Oxford.
- Gjelland, K. Ø., Bøhn, T., and Knudsen, Frank Reier and Amundsen, P.-A. 2004. Influence of light on the swimming speed of coregonids in Subarctic lakes. *Ann. Zool. Fennici*, 41(February), 137–146.
- Glass, C. W., and Wardle, C. S. 1995. Studies on the use of visual stimuli to control fish escape from codends. In: The effect of a black tunnel on the reaction behaviour of fish in otter trawl codends. *Fisheries Research*, 23: 165–174.
- Glass, C. W., Wardle, C. S., Gosden, S. J., and Racey, D. N. 1995. Studies on the use of visual stimuli to control fish escape from codends. In: Laboratory studies on the effect of a black tunnel on mesh penetration. *Fisheries Research*, 23: 157–164.
- Glass, C. W., Wardle, C. S. 1989. Comparison of the Reactions of Fish to a Trawl Gear, at High and Low Light Intensities. *Fisheries Research*, 7: 249–266.

- Gless, J., Salmon, M., and Wyneken, J. 2008. Behavioral responses of juvenile leatherbacks *Dermochelys coriacea* to lights used in the longline fishery. *Endangered Species Research*, 5 (December), 239–247. doi:10.3354/esr00082
- Gordon, J. D. M., Bergstad, O. A. and Pascoe, P. L. 2002. The influence of artificial light on the capture of deep-water demersal fish by bottom trawling. *J. Mar. Biol. Ass. UK*, 82: 339–344.
- Grinnell, A. D., Narins, P. M., Awbrey, F. T., Hamner, W. M., and Hamner, P. P. 1988. Eye/Photophore Coordination and Light- following in Krill, *Euphausia Superba*. *J. exp. Biol.*, 134: 61–77.
- Gustafsson, O. S. E. 2010. Evolution of vertebrate eyes: A Study on lens suspension and optical properties. Doctoral Thesis, Dept. of Biol., University of Lund 2010.
- Gyekis, K. F., Cooper, M. J., and Uzarski, D. G. 2006. A high-intensity LED light source for larval fish and aquatic invertebrate floating quatrefoil light traps. *Journal of Freshwater Ecology*, 21(4): 621–626.
- Hadderingh, R. H. 1982. Experimental reduction of fish impingement by artificial illumination at bergum power station (scan).pdf. *Int. Revue ges. Hydrobiol*, 67(6): 887–900.
- Handegard, N. O., and Williams, K. 2008. Automated tracking of fish in trawls using the DID-SON (Dual frequency IDentification SONar). *ICES Journal of Marine Science*, 65(4): 636–644. doi:10.1093/icesjms/fsn029
- Hasegawa, E. 1998. Study on Measurement of Spectral Sensitivity under Scotopic Conditions Using Optomotor Reaction in Fish. *Nippon Suisan Gakkaishi*, 64(4): 626–630.
- Hasegawa, E. I. 2006. Comparison of the spectral sensitivity of three species of juvenile salmonids. *Journal of Fish Biology*, 68(6): 1903–1908. doi:10.1111/j.1095-8649.2006.01083.x
- Hasegawa, Eiichi. 1993. Effect of Light upon the Behavior of Fish in Twilight Vision. *Nippon Suisan Gakkaishi*, 59(9): 1509–1514.
- Hasegawa, E., Kobayashi, H., and Niwa, H. 1991. Comparison of Retinal Adaptation in Chub Mackerel and Sardine Attracted to a Fishing Lamp Previous and Subsequent to Midnight. *Nippon Suisan Gakkaishi*, 57(3): 425–431.
- Haymes, G. T., Patrick, P. H., Onisto, L. J. 1984. Attraction of fish to mercury vapour light and its application in a generating station forebay scan.pdf. *ICES Journal of Marine Science*, 69(6): 867–876.
- Hazin, H. G., Hazin, F. H. V., Travassos, P., and Erzini, K. 2005. Effect of light-sticks and electrolume attractors on surface-longline catches of swordfish (*Xiphias gladius*, Linnaeus, 1959) in the southwest equatorial Atlantic. *Fisheries Research*, 72(2–3): 271–277. doi:10.1016/j.fishres.2004.10.003
- Hovda, J. I., and Fosshagen, A. 2010. Hyperbenthic calanoids and *Thespesiopsyllus paradoxus* (Sars) collected with a light trap in western Norway light trap in western Norway. *October*, (August 2011), 37–41. doi:10.1080/00364820310000300
- Inada, H. 1988. Measurement of the Underwater Spectral Irradiance under the Squid Jigging Boat (Abstract only). *Journal of the Tokyo University of Fisheries*, 75(2): 487–498.
- Inada, H., and Ogura, M. 1988. Historical changes of fishing light and its operation in squid jigging fisheries. (abstract only). *Rep. Tokyo Univ. Fish.*, 24: 189–207.
- Inada, H., and Arimoto, T. 2007. Trends on Research & Development of Fishing Light in Japan. *J. Illum. Eng. Inst. Japan*, 91(4): 199–209.
- Jamieson, A. J., Godø, O. R., Bagley, P. M., Partridge, J. C., and Priede, I. G. 2006. Illumination of trawl gear by mechanically stimulated bioluminescence. *Fisheries Research*, 81(2–3): 276–282. doi:10.1016/j.fishres.2006.06.021
- Jech, J. M., Kotwicki, S., De Robertis, A., von Szalay, P., and Towler, R. 2009. The effect of light intensity on the availability of walleye pollock (*Theragra chalcogramma*) to bottom trawl and

- acoustic surveys. *Canadian Journal of Fisheries and Aquatic Sciences*, 66(6): 983–994. doi:10.1139/F09-055
- Jo, H.-S., Kim, D.-N., Cho, Y.-B., Lee, J.-H., Kim, H.-seok, Yang, W.-S., An, H.-C., *et al.* (2004). Transmittance properties of fishing lamp in stick-held dip net fishing vessel for pacific saury. *Bulletin of the Korean society of Fisheries Technology*, 40(1): 23–28.
- Jo, H.-S., *et al.* 2004. Transmittance properties of fishing lamp in stick-held dip net fishing vessel for Pacific saury. *Bulletin of the Korean society of Fisheries Technology*, 40(1): 23–28.
- Jo, H.-S. *et al.* 2006. Transmittance properties of fishing lamp in distant-water squid jigging vessel (Korean). *J. Kor. Soc. Fish. Tech.*, 42(4): 228–233.
- Johnson, R. L., Mckinstry, C. A., Cook, C. B., Tano, D. K., Faber, D. M., Francis, S., Simmons, M. A., *et al.* 2005. *Strobe Light Deterrent Efficacy Test and Fish Behavior Determination at Grand Coulee Dam Third Powerplant Forebay*. Contract (p. 139).
- Jokela, M. 2003. Polymorphism of the rod visual pigment between allopatric populations of the sand goby (*Pomatoschistus minutus*): a microspectrophotometric study. *Journal of Experimental Biology*, 206(15): 2611–2617. doi:10.1242/jeb.00472
- Kaartvedt, S., Røstad, A., Fiksen, Ø., Melle, W., Torgersen, T., Breien, M. T., and Klevjer, T. A. 2005. Piscivorous fish patrol krill swarms. *Marine Ecology Progress Series*, 299: 1–5.
- Kasumyan, A. O. 2009. Acoustic signaling in fish. *Journal of Ichthyology*, 49(11): 963–1020. doi:10.1134/S0032945209110010
- Kawamura, G., Matsushita, T., Nishitai, M., and Matsuoka, T. 1996. Blue and green fish aggregation devices are more attractive to fish. *Fisheries Research*, 28(1): 99–108. doi:10.1016/0165-7836(96)00478-X
- Kim, Y.-H., and Wardle, C. 1998a. Measuring the brightness contrast of fishing gear, the visual stimulus for fish capture. *Fisheries Research*, 34(2): 151–164. doi:10.1016/S0165-7836(97)00087-8
- Kim, Y.-H., and Wardle, C. 1998b. Modelling the visual stimulus of towed fishing gear. *Fisheries Research*, 34(2): 165–177. doi:10.1016/S0165-7836(97)00089-1
- Koike, T., and Kanau, M. 1987. Response of a Fish School to Different Blinking Frequencies and Intensity Ratios of Intermittent Light. *Nippon Suisan Gakkaishi*, 53(6): 925–932.
- Korsbrekke, K., and Nakken, O. 1999. Length and species-dependent diurnal variation of catch rates in the Norwegian Barents Sea bottom-trawl surveys. *ICES Journal of Marine Science*, 56: 284–291.
- Krag, L. A., Holst, R., Madsen, N., Hansen, K., and Frandsen, R. P. 2010. Selective haddock (*Melanogrammus aeglefinus*) trawling: Avoiding cod (*Gadus morhua*) bycatch. *Fisheries Research*, 101(1–2): 20–26. doi:10.1016/j.fishres.2009.09.001
- Kröger, R. H. H., Campbell, M. C. W., Fernald, R. D., and Wagner, H. J. 1999. Multifocal lenses compensate for chromatic defocus in vertebrate eyes. *J. Comp. Physiol. A.*, 184: 361–369.
- Kröger, R. H. H., Knoblauch, B., Wagner, H.-J. 2003. Rearing in different photic and spectral environments changes the optomotor response to chromatic stimuli in the cichlid fish *equidens pulcher*. *J. Exp. Biol.*, 206: 1643–1648.
- Longcore, T., and Rich, C. 2004. Ecological light pollution. *Front Ecol. Environ.*, 2(4): 191–198.
- Løkkeborg, S, Skajaa, K., and Fernö, A. 2000. Food-search strategy in ling (*Molva molva* L.): crepuscular activity and use of space. *Journal of experimental marine biology and ecology*, 247(2): 195–208. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/10742504>
- Løkkeborg, Svein, and Fernö, A. 1999. Diel activity pattern and food search behaviour in cod *Gadus morhua*. *Environmental Biology of Fish*, 54: 345–353.

- Marchesan, M., Spoto, M., Verginella, L., and Ferrero, E. A. 2005. Behavioural effects of artificial light on fish species of commercial interest. *Fisheries Research*, 73(1–2): 171–185. doi:10.1016/j.fishres.2004.12.009
- Matsuda, K., Torisawa, S., Hiraishi, T., and Yamamoto, K. 2008. Comparison of the color vision and spectral sensitivity of three flatfish species of different ecotypes, and application to selective fishing methods. *Fisheries Science*, 75(1): 35–42. doi:10.1007/s12562-008-0008-6
- Matsuoka, T., Ishizuka, S., Anraku, K., and Nakano, M. 1996. Assessment by underwater infrared video of the selectivity of an experimental Danish seine for deep-water prawn. *2nd World Fisheries Congress* (pp. 551–557). Canberra.
- Matsushita, Y., Azuno, T., and Yamashita, Y. 2012. Fuel reduction in coastal squid jigging boats equipped with various combinations of conventional metal halide lamps and low-energy LED panels. *Fisheries Research*, 125–126, 14–19. doi:10.1016/j.fishres.2012.02.004
- McConnell, A., Routledge, R., and Connors, B. 2010. Effect of artificial light on marine invertebrate and fish abundance in an area of salmon farming. *Marine Ecology Progress Series*, 419(Carss 1990): 147–156. doi:10.3354/meps08822
- Meager, J. J., Moberg, O., Strand, E., Utne-Palm, A. C. 2010. Effects of light intensity on visual prey detection by juvenile Atlantic cod. *Marine & Freshwater Behaviour & Physiology*, 43(2): 99–108.
- Mercer, R.W., and M. Bucy. 1983. Experimental squid jigging off the Washington coast. *Mar. Fish. Rev.*, 45(7–9): 56–62.
- Mesquita, F. D. O., Godinho, H. P., Azevedo, P. G. D., and Young, R. J. 2008. A preliminary study into the effectiveness of stroboscopic light as an aversive stimulus for fish. *Applied Animal Behaviour Science*, 111(3–4): 402–407. doi:10.1016/j.applanim.2007.06.014
- Michalsen, K., Godø, O. R., and Fernø, A. 1996. Diel variation in the catchability of gadoids and its influence on the reliability of abundance indices. *ICES Journal of Marine Science*, 53: 389–395.
- Olla, B. L., Davis, M. W., and Rose, C. 2000. Differences in orientation and swimming of walleye pollock *Theragra chalcogramma* in a trawl net under light and dark conditions: concordance between field and laboratory observations. *Fisheries Research*, 44: 261–266.
- Olla, B. L., Davis, M. W., and Schreck, C. B. 1997. Effects of simulated trawling on sablefish and walleye pollock: the role of light intensity, net velocity and towing. *Journal of Fish Biology*, 50: 1181–1194.
- Owen, M. A. G., Davies, S. J., and Sloman, K. A. 2009. Light colour influences the behaviour and stress physiology of captive tench (*Tinca tinca*). *Reviews in Fish Biology and Fisheries*, 20(3): 375–380. doi:10.1007/s11160-009-9150-1
- Park, K. 2000. Quantifying of photon Flux Emission from LED using a quantum sensor and spectroradiometer.pdf. *J. Bio-Env. Control*, 9(4): 223–229.
- Parrish, J. K. 1999. Using behaviour and ecology to exploit schooling fish.pdf. *Environmental Biology of Fish*, 55: 157–181.
- Parry, J. W. L., Carleton, K. L., Spady, T., Carboo, A., Hunt, D. M., and Bowmaker, J. K. 2005. Mix and match color vision: tuning spectral sensitivity by differential opsin gene expression in Lake Malawi cichlids. *Current biology: CB*, 15(19): 1734–9. doi:10.1016/j.cub.2005.08.010
- Parsons, G. R., Foster, D. G. 2007. Swimming Performance and Behavior of Red Snapper: Their Application to Bycatch Reduction. *American Fisheries Society Symposium*, 60: 59–75.
- Patrick, P. H., Sheehan, R. W., and Sim, B. 1982. Effectiveness of a strobe light eel exclusion scheme. *Hydrobiologia*, 94(3): 269–277. doi:10.1007/BF00016408
- Patrick, P. H. et al. 1985. Response of fish to a strobe light air-bubble barrier. *Fisheries Research*, 3: 157–172.

- Petrakis, G. 2001. Day–night and depth effects on catch rates during trawl surveys in the North Sea. *ICES Journal of Marine Science*, 58(1): 50–60. doi:10.1006/jmsc.2000.0989
- Piepho, M., Martin-Creuzburg, D., and Wacker, A. 2010. Simultaneous effects of light intensity and phosphorus supply on the sterol content of phytoplankton. *PloS one*, 5(12), e15828. doi:10.1371/journal.pone.0015828
- Pitcher, T. J., and Parrish, J. K. 1993. The functions of shoaling behaviour. In *The behaviour of teleost fish*, 2nd ed. pp. 363–439. Ed. by T. J. Pitcher. Chapman and Hall, London. 715 pp.
- Poisson, F. *et al.* 2009. Effects of lunar cycle and fishing operations on longline-caught pelagic fish: fishing performance, capture time, and survival of fish. *Fishery Bulletin*, 108(3): 268–281.
- Punt, E., Wilson, C. D., Horne, J. K., and Williams, K. 2011. Length-selective retention of wall-eye pollock, *Theragra chalcogramma*, by midwater trawls. *ICES Journal of Marine Science*, 68(1): 119–129. doi:10.1093/icesjms/fsq155
- Richards, N. S., Chipps, S. R., and Brown, M. L. 2007. Stress Response and Avoidance Behavior of Fish as Influenced by High-Frequency Strobe Lights. *North American Journal of Fisheries Management*, 27(4): 1310–1315. doi:10.1577/M06-239.1
- Rodhouse, P. G., Elvidge, C. D., Trathan, P. N. 2001. Remote Sensing of the Global Light-Fishing Fleet: An Analysis of Interactions with Oceanography, other Fisheries and Predators. *Advances in Marine Biology*, 39: 262–303.
- Rose, C. S., Stoner, A. W., and Matteson, K. 2005. Use of high-frequency imaging sonar to observe fish behaviour near baited fishing gears. *Fisheries Research*, 76(2): 291–304. doi:10.1016/j.fishres.2005.07.015
- Ryer, C. H., and Olla, B. L. 2000. Avoidance of an approaching net by juvenile walleye pollock *Theragra chalcogramma* in the laboratory: the influence of light intensity. *Fisheries Research*, 45: 195–199.
- Ryer, C., Stoner, A., Iseri, P., and Spencer, M. 2009. Effects of simulated underwater vehicle lighting on fish behavior. *Marine Ecology Progress Series*, 391(2008): 97–106. doi:10.3354/meps08168
- Sager, David R., Hocutt, C. H., and Stauffer, J. R. 2000. Avoidance behaviour of *Morone americana*, *Leiostomus xanthurus* and *Brevoortia tyrannus* to strobe light as a method of impingement mitigation. *Environmental Science & Policy*, 3(S): 393–403.
- Sager, D.R. *et al.* 1987. Estuarine fish response to strobe light, bubble curtains and strobe light/bubble curtains combinations as influenced by Water Flow Rate and Flash Frequencies. *Fisheries Research*, 5, 383–399.
- Schartau, J. M., Kroger, Ronald. H. H., and Sjogreen, B. 2010. Dopamine Induces Optical Changes in the Cichlid Fish Lens. *PloS one*, 5(4). doi:10.1371/Citation
- Schilt, C. R. 2007. Developing fish passage and protection at hydropower dams. *Applied Animal Behaviour Science*, 104(3–4): 295–325. doi:10.1016/j.applanim.2006.09.004
- Schmidt, M. B., Balk, H., and Gassner, H. 2009. Testing in situ avoidance reaction of vendace, *Coregonus albula*, in relation to continuous artificial light from stationary vertical split-beam echosounding. *Fisheries Management and Ecology*, 16(5): 376–385. doi:10.1111/j.1365-2400.2009.00689.x
- Shikata, T., Shima, T., Inada, H., Miura, I., Daida, N., Sadayasu, K., and Watanabe, T. 2011. イカ釣り操業時に船上灯光により形成される船底下陰影部の スルメイカの誘集 □ 釣獲過程における役割. *Nippon Suisan Gakkaishi*, 77: 53–60.
- Stiansen, S., Fernö, A., Furevik, D., Jørgensen, T., and Løkkeborg, S. 2010. Transactions of the American Fisheries Society Horizontal and Vertical Odor Plume Trapping of Red King Crabs Explains the Different Efficiency of Top- and Side- Entrance Pot Designs. *Transactions of the American Fisheries Society*, 139(2): 483–490.

- Stoner, A. 2004. Effects of environmental variables on fish feeding ecology: implications for the performance of baited fishing gear and stock assessment. *Journal of Fish Biology*, 65: 1445–1471. doi:10.1111/j.1095-8649.2004.00593.x
- Stoner, A. W., Ryer, C. H., Parker, S. J., Auster, P. J., and Wakefield, W. W. 2008. Evaluating the role of fish behavior in surveys conducted with underwater vehicles. *Canadian Journal of Fisheries and Aquatic Sciences*, 65(6): 1230–1243. doi:10.1139/F08-032
- Sugimura, N. O., Yamashita, Y. U., and Kurihara, K. O. 2005. LED 点滅光によるマダイの侵入抑制効果. *Nippon Suisan Gakkaishi*, 71(2): 188–197.
- Swimmer, Y., Arauz, R., Higgins, B., Naughton, L. M., Mccracken, M., Ballesterio, J., and Brill, R. 2005. Food color and marine turtle feeding behavior : Can blue bait reduce turtle by-catch in commercial fisheries ? *Marine Ecology Progress Series*, 295: 273–278.
- Swinney, G. N., Clarke, M. R., and Maddock, L. 1986. Influence of an electric light on the capture of deep-sea fish in Biscay. *J. Mar. Biol. Ass. UK*, 66: 483–496.
- Takashi Koike and Kanau Matsuike. 1988. Response of a Fish School to Different Wavelengths of Intermittent Lights and Different Background Irradiances under Projected Light . * 1 , 2. *Nippon Suisan Gakkaishi*, 54(5): 829–835.
- The Mendeley Support Team. (2011). Getting Started with Mendeley. *Mendeley Desktop*. London: Mendeley Ltd. Retrieved from <http://www.mendeley.com>
- Utne-Palm, A. C., and Bowmaker, J. K. 2006. Spectral sensitivity of the two-spotted goby *Gobiusculus flavescens* (Fabricius): a physiological and behavioural study. *The Journal of experimental biology*, 209(Pt 11): 2034–41. doi:10.1242/jeb.02171
- Vilizzi, L., Meredith, S. N., Sharpe, C. P., and Rehwinkel, R. 2008. Evaluating light trap efficiency by application of mesh to prevent inter- and intra-specific in situ predation on fish larvae and juveniles. *Fisheries Research*, 93(1–2): 146–153. doi:10.1016/j.fishres.2008.03.011
- Vinebrooke, R., Novales Flamarique, I., Gulbransen, C., Galbraith, M., and Stucchi, D. 2009. Monitoring and potential control of sea lice using an LED-based light trap. *Canadian Journal of Fisheries and Aquatic Sciences*, 66(8): 1371–1382. doi:10.1139/F09-094
- Wagner, H.-J., and Kröger, R. H. H. 2005. Adaptive plasticity during the development of colour vision. *Progress in retinal and eye research*, 24(4): 521–536. doi:10.1016/j.preteyeres.2005.01.002
- Walsh, S. J. 1991. Diel variation in availability and vulnerability of fish to a survey trawl (scan - ikke søkbar).pdf. *J. Appl. Ichthyol.*, 7: 147–159.
- Walsh, S.J., Hickey, W. M. 1993. Behavioural reactions of demersal fish to bottom trawls at various light conditions (scan - ikke søkbar).pdf. *ICES mar. Sci. Symp.*, 196: 68–76.
- Weinberg, K. L., and Munro, P. T. 1999. The effect of artificial light on escapement beneath a survey trawl. *ICES Journal of Marine Science*, 56: 266–274.
- Widder, E. A., Robison, B. H., Reisenbichler, K. R., and Haddock, S. H. D. 2005. Using red light for in situ observations of deep-sea fish. *Deep Sea Research Part I: Oceanographic Research Papers*, 52(11): 2077–2085. doi:10.1016/j.dsr.2005.06.007
- Wiebe, P. H., Ashjian, C. J., Gallagher, S. M., Davis, C. S., Lawson, G. L., and Copley, N. J. 2004a. Using a high-powered strobe light to increase the catch of Antarctic krill. *Marine Biology*, 144(3): 493–502. doi:10.1007/s00227-003-1228-z
- Williams, K., Punt, a. E., Wilson, C. D., and Horne, J. K. 2010. Length-selective retention of walleye pollock, *Theragra chalcogramma*, by midwater trawls. *ICES Journal of Marine Science*, 68(1): 119–129. doi:10.1093/icesjms/fsq155
- Williamson, C. E., Fischer, J. M., Bollens, S. M., Overholt, E. P., and Breckenridge, J. K. 2011. Towards a more comprehensive theory of zooplankton diel vertical migration: Integrating ultraviolet radiation and water transparency into the biotic paradigm. *Limnology and Oceanography*, 56(5): 1603–1623. doi:10.4319/lo.2011.56.5.1603

- Yamashita, Y., Matsushita, Y., and Azuno, T. 2012a. Catch performance of coastal squid jigging boats using LED panels in combination with metal halide lamps. *Fisheries Research*, 113(1): 182–189. Elsevier B.V. doi:10.1016/j.fishres.2011.10.011
- Yamashita, Y., Matsushita, Y., and Azuno, T. 2012b. Catch performance of coastal squid jigging boats using LED panels in combination with metal halide lamps. *Fisheries Research*, 113(1), 182–189. Elsevier B.V. doi:10.1016/j.fishres.2011.10.011
- Yokota, K., Kiyota, M., and Okamura, H. 2009. Effect of bait species and color on sea turtle bycatch and fish catch in a pelagic longline fishery. *Fisheries Research*, 97(1–2): 53–58. doi:10.1016/j.fishres.2009.01.003
- Zhang, X. M., and Arimoto, T. 1993. Visual physiology of walleye pollock in relation to capture by trawl nets (scan - ikke søkbar).pdf. *ICES mar. Sci. Symp.*, 196: 113–116.
- Øynes, P. 1972. Composition of Fish Species in Purse Seine Catches Obtained by Use of Artificial Light in Fjords in Western Norway. *Fiskets Gang*, 58: 903–912.